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ERRATA.

Page 183, l. 18 from bottom, for "Palagia," read "Falagria;" l. 16 fr. bot. for "flavicernis," read "flavicornis." P. 185, l. 17 fr. bot. for "æreola," read "æneola;" l. 11 fr. bot. for "Athoiis," read "Athous;" l. 10 fr. bot. for "æreolus," read "æneolus." P. 291, l. 21 fr. top, for "contradiction," read "contraction."

THE

AMERICAN

JOURNAL OF SCIENCE, &c.

Art. I.—*On the Physical Geology of the United States east of the Rocky Mountains, and on some of the Causes affecting the Sedimentary Formations of the Earth;* by William W. Mather, Professor of Natural Sciences in the Ohio University, Athens, Ohio.*

Part I. *On the Causes of the great Currents of the Ocean, and their Influence in the Transport and Deposition of the Sedimentary Rocks of the United States.*

It is well known to those who have attended to the geological structure of our country, either by reading or observation, that the whole territory of the United States south of the great lakes and the St. Lawrence river, and between the Rocky Mountains on the west, and the Blue Ridge, the Highlands of New Jersey and New York, and the Green Mountains on the east,

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* In discussing the subjects suggested in the title of our article, in this and some subsequent Nos. of this Journal, it will be found convenient to adopt the following divisions:—

I. On the causes of the great currents of the ocean, and their influence in the transport and deposition of the sedimentary rocks of the United States.

II. On the causes of elevation of the sedimentary rocks above the level of the sea, and of the plications and foldings of strata, particularly those of the United States.

III. On the periods during which these elevations, plications, and foldings of the strata occurred.

IV. On the metamorphic changes that the sedimentary and other rocks have undergone since their deposition and elevation.

The first and second parts were read before the National Institute at Washington, D. C. in April, and before the Association of American Geologists and Naturalists in May, 1844.

is composed of sedimentary rocks* which have been formed by the aid of water, and organic secretion.

Attempts have been made to measure the thickness of these rocks in Pennsylvania, Virginia, New York, and Ohio. The measurements in Pennsylvania give a thickness that excites astonishment, (seven to nine miles.) Those of central New York and Ohio, where the rocks are nearly horizontal, and undisturbed since their deposition, indicate a less thickness; but eight thousand feet in New York, and four thousand to five thousand feet in Ohio, is about the average thickness of these sedimentary rocks, and they are spread over an area of at least one million of square miles in the United States, exclusive of their extent in Texas, Mexico, and the British possessions.

These rocks vary in texture from a coarse conglomerate to the finest clays and shales. Several rocks of the same kinds, as sandstones, limestones, slates, coal, &c. are repeated many times, yet each differs from the others of the same kind by some slight peculiarities, by which they may be recognized by careful study.

Whatever may have been the causes of the formation and deposition of these rocks, it is evident that they have been so modified in their action as to produce limestones at one time over nearly the whole of the vast area under consideration,—slates at another period, succeeded by sandstones,—again by limestones, slates, and sandstones,—and still again by conglomerates, slates, sandstones, coal, and iron ore, some of them alternating and repeated many times. Similar causes have acted repeatedly over the same areas.

The sand of the sandstones could be spread over such vast areas only by means of some cause tending to produce a broad current of moderate velocity;† the conglomerate would imply a

* It is necessary here to make exceptions of limited tracts in Georgia, Missouri, and Arkansas, where primary and metamorphic rocks occur; also the mountain region of northeastern New York. These masses of primary and metamorphic strata stand as geological islands surrounded by sedimentary rocks.

† *Table showing the Transporting Power of Currents.*

POWER OF TRANSPORT.	VELOCITY OF CURRENTS.	
	Inches per second.	Miles per hour.
Wears away fine, compact, tough clay, ...	3	0·17
Removes fine sand, ...	6	0·34
" sand as coarse as flax-seed, ...	8	0·45
" fine gravel, ...	12	0·68
" pebbles an inch in diameter, ...	24	1·36
" angular fragments 2 or 3 inches in diameter,	36	2·14

more rapid flow, while the slates and shales whose particles are very minute, and would remain long in suspension, required still and nearly tranquil waters.

The limestone deposits have been formed in the thickest masses, where circumstances were favorable to the life of testaceous and radiated marine animals, of whose remains they are in part composed. Thick strata of limestone which are continuous and of the same geological age, abound with marine relics in one portion of the country, and are nearly destitute of them in another. It is therefore probable that although organic secretion *aided* in the formation of the limestone, it is not the sole cause.

Testacea and Radiata are also found in some of the sandstones and slates, but they are comparatively rare. The sandstones and slates, however, are frequently found to contain abundance of the remains of the vegetable kingdom.

All this great mass of rocks over an area of more than a million of square miles, and several thousands of feet in thickness, is composed of the wrecks of older rocks (except the parts of organic origin) that have been disintegrated, ground up by attrition, washed away and deposited from suspension in water over the vast area where we now find them. Each layer of these rocks must once have been the bed of the ocean, over which at successive times and under modified circumstances, these various materials have been deposited in succession, to form the immense mass now exposed to the observation of man, many of the strata of which are some hundreds of feet above the level of the sea. It is evident that these rocks were formed in the ocean, for the following reasons.

1st. They are filled with the relics of animals such as are analogous to those living in the sea, and not to those of the fresh water.

2d. These relics are so perfect that many of them must have lived, died, and been entombed where we now find them.

3d. The materials of which the rocks are composed, are such as are commonly transported, and held in suspension and solution in water.

4th. The oblique lamination of the sandstones shows the directions of the currents that deposited them.

5th. At almost every point of the area mentioned, where deep borings have been made far below the flowing waters of the adjoining valleys, salt water has been found, containing the same impurities as the waters of the ocean.* This salt water, on account of its greater specific gravity than common water, might be expected to remain, filling the pores and vacuities of the rocks, the particles of which had been deposited in the bottom of the ocean.

A minute examination of the sedimentary rocks, shows that they are composed of the fragments and comminuted grains of older and well known rocks, which have been washed away and deposited far from their original situations.

Whence has this immense mass of fragments of older rocks been derived, that is found to have been deposited over this vast area in the United States? Are there any causes known, adequate to explain its origin?

It may be said in answer, that there are data known from which we may reason with a probability of attaining an approximation to truth. This subject is one that has scarcely been broached, and the causes that will be adduced as having probably produced the transportation and deposition of a mass of such great thickness and extent, are such as may have been equally active on other parts of the earth's surface.

Before entering fully into this subject, it is necessary to consider some of the dynamical causes that may have had an influence in the production of the numerous and extensive sedimentary deposits upon the surface of the globe.

1st. It is generally admitted that the earth is a cooling body; at least that its surface has a much higher mean temperature than the regions of space in which it performs its revolutions around the sun; that the temperature increases rapidly from near its surface towards its centre; and that it loses more caloric by radiation than it receives from the sun;—in all which respects it is in the state of a cooling body.

2d. Cooling bodies diminish in volume.

3d. Bodies revolving on axes if diminished in volume, the quantity of matter remaining constant, revolve with increased angular velocities.

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* I have found bromine and iodine in several of the salt springs of Ohio. I have lately made some quantity of salts of bromine, and separated the pure bromine from the bittern of the salt springs near Athens, Ohio. The usual saline substances of bittern are found in these springs except sulphates.

If we apply these principles to the earth, which may be admitted to be a cooling and revolving body, it must have diminished in volume either secularly or paroxysmally. This must necessarily have induced a greater velocity of rotation on its axis, also an increased centrifugal force, and the oblateness of the spheroidal form of the earth must have been increased in the same proportion.*

The increased oblateness of the spheroidal form of the earth by the increase of the centrifugal force, would induce a flow of water from the polar to the tropical parts of the earth to restore the form of equilibrium of the revolving spheroid under these modified conditions; and as the earth revolves from W. to E. these currents from the polar regions would bend more and more to the westward as they advanced to lower and lower latitudes, and a current would set from E. to W. within the tropics, but strongest under the equator.†

The polar and equatorial currents, branches of which are believed to have been observed in every ocean, but variously modified in direction by numerous causes, may have been thus established or heightened in the rapidity of their flow at particular epochs in the earth's history.

Another cause that may have been instrumental in the first instance in establishing, and subsequently in maintaining the flow of the polar and equatorial and other currents of the ocean, is the influence of the solar rays on the tropical regions of the earth. This influence is exerted both on the atmosphere and on the ocean, but both concur in aiding the flow of the currents under consideration. The water of the ocean being warmed more under the tropics than on other parts of the earth's surface, expands,‡

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* $F = \frac{V^2}{\gamma}$. If t represents the time of rotation, $V = \frac{2\pi\gamma}{t}$ and by substitution, $F = \frac{4\pi^2\gamma}{t^2} \therefore F : F' :: \frac{\gamma}{t^2} : \frac{\gamma'}{t'^2}$. These formulæ show that the centrifugal force varies directly as the square of the velocity of any point, and inversely as the distance of that point from the axis of motion; and also that the centrifugal forces vary directly as the distance from the axis of rotation, and inversely as the squares of the times of rotation.

† The reason of this deflection of currents will be explained farther on in this article.

‡ It has been objected that the evaporation from the surface of the ocean under the tropics would compensate for this expansion; but it would be insufficient if the water becomes heated to 80° to any considerable depth. The quantity of water that falls as rain, also in part compensates for the evaporation.

and tends to flow off towards the polar regions, while an underflow of colder and heavier water restores the equilibrium.

The real effects of this cause may be deemed theoretically true without having any sensible influence; but the *geological* effects in the development of organic life, when considered in connection with the flow produced by other causes, are not unimportant, and will be considered in another place.

The effect of the solar rays upon the atmosphere, particularly under the tropics, is to produce a rarefaction of the air, and ascending currents that flow off toward the polar regions, and a counter flow from the polar towards the tropical regions, restores the equilibrium.*

The northwardly compensating current of the atmosphere over the eastern part of the Atlantic Ocean, as it reaches successively lower latitudes, bends more and more to the westward until under the tropics it forms the *trade wind.*† This sweeps to the westward and by its constancy and moderate limits of variation in direction, gives great aid to the equatorial current of the ocean, and is perhaps more effective in producing and maintaining this current than any of the other causes.

Another cause may be adduced for the westward flow of the equatorial current, viz. the current that flows southwardly along the eastern part of the north Atlantic, and that flowing northwardly from the Lagullas banks along the coast of the southwest

* This is the commonly received theory. Many facts are in opposition to this theory and seem irreconcilable with it; but of the great circular flow of the currents of the atmosphere and smaller secondary gyrating currents, there is no doubt, and change of temperature and the rotation of the earth are the main causes. Vide Mr. Redfield's papers, Am. Jour. Science, Vols. XXV and XLV.

† Mr. Espy accounts for the trade winds on another principle, viz. that the upward ascending currents as they reach higher elevations and are more remote from the axis of rotation of the earth, have by their inertia a different *linear velocity* from that due to a point rotating at that distance from the axis with the same *angular velocity*, and as the earth rotates from W. to E., these uprising columns of rarefied air have a relative retrograde motion with regard to the surface of the earth, giving rise to a general westwardly motion of the air under the tropics. This cause however can have but little influence in the production of the trade winds, for, if we suppose uprising columns of air to exist and to ascend twenty miles in height, which is far more than we have any evidence of in the clouds, the increased velocity due to a point at this distance would be only 62·83 miles more in twenty four hours, than that of a point on the surface at the equator, or less than three miles per hour, which would produce a retrograde or westwardly wind scarcely perceptible *there*, and would influence the currents near the surface of the earth still less, in an almost infinitesimal degree.

part of Africa and towards St. Helena and Ascension, meet nearly in opposition to each other under the tropics; and although the velocity of the currents is small, the opposite momenta have a tendency to elevate the waters of the ocean higher than the true water level, the same as when a tide is obstructed by a coast, it rises higher than it would if unobstructed. The tendency of the water to restore the equilibrium would be to the westward and to the eastward. The flow to the *eastward* is partially obstructed by the African coast, but the eastward current by Cape Palmas and Cape Threepoints, and around the Gulf of Guinea, may be caused in part by this tendency.* The flow to the *westward* in the direction of the equatorial current, is the one by which the equilibrium is mostly restored, for two reasons; 1st, the flow in that direction is unobstructed; and 2d, the waters coming from higher latitudes, where the linear rotative velocity of the earth's surface is less than under the tropics, the tendency of the water is to flow to the westward.

Another cause tending to aid in the production of the polar and equatorial currents may be adduced, although its real influence may be very minute. The evaporation from the tropical regions of the earth exceeds the amount condensed as rain, fog, and dew, and this excess is carried to the temperate and frigid zones by the great currents of the atmosphere, where it is condensed as rain, snow, fog, and dew. The excess of water deposited from the atmosphere in the extra-tropical regions, more than is evaporated, falls and flows into the ocean. The ocean level in those regions, particularly along coasts where large rivers debouche, may be said to be slightly raised above the level of the spheroidal form of equilibrium of the earth, and the water in consequence of its mobility, will tend to flow from the polar and temperate zones towards the tropics.

All the various causes that have been mentioned as influencing the great currents of the ocean and atmosphere, (and which are the legitimate results of the action of gravitation, variations of temperature, and inertia, while the earth revolves on its axis,) concur in their effects, and are believed to be the true causes of the Gulf Stream and the great currents of the ocean. The cur-

* Currents have been observed between Cape Palmas and Cape of Good Hope, indicating with much probability a gyrating mass of waters in a great eddy between Cape Palmas, Cape Formosa, Cape Negro, and St. Helena.

rents both of the ocean and the atmosphere have a tendency to a circular flow; those flowing from the equatorial toward the polar regions bend more and more to the eastward as they advance into higher latitudes, while those flowing from the poles towards the equator, bend to the westward as they approach the tropical regions. This may be seen in the southwest winds of the United States and the Gulf Stream, in one case—and in the prevailing currents of the atmosphere and of the Atlantic Ocean, that cause the trade winds and the equatorial current, in the other.*

The bending of these currents of the ocean and of the atmosphere to the eastward in the northwardly flow, and to the

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* In regard to the great currents of the ocean, the following are said to have been distinctly recognized as permanent, and with slight variations in velocity. Numerous local and variable currents have been noticed, which are caused by subdivisions and deflections of the more general ones, and by those causes that produce eddies. Theory would render others probable that have not been recognized.

A. (1.) The equatorial current of the Atlantic is divided by the eastern coast of South America into two branches. The larger flows to the W. and N. W. into the Caribbean Sea and Gulf of Mexico, causing a higher level than that of equilibrium, and a flow through the Gulf of Florida called the Gulf Stream; the other flows along the coast of Brazil toward Sandwich Land.

(2.) The equatorial current of the Pacific has a very moderate westward flow, which is nearly uniform and constant, like the trade winds in the central and western parts of that ocean.

Branches of this current are said to set northward along the coasts of China and Japan, corresponding to the Gulf Stream; and southward by New Holland toward the Antarctic regions.

(3.) The equatorial current of the Indian Ocean has a northwest flow, caused by a deflection of the same current from the Pacific among the reefs and islands between which a part of it passes, and by the southwardly polar current. The northwest current flows west from Cape Comorin to the African coast, thence along that coast through the Mozambique Channel to the Lagullas Banks near the Cape of Good Hope, where it meets the Lagullas current from the Antarctic seas. Numerous counter and variable currents are also found in the Indian Ocean.

B. (1.) The polar current from the north issues from Davis's Strait and floats icebergs even against the wind, and against the Gulf Stream in the vicinity of the Banks of Newfoundland. This current proceeds southwardly, and owing to the rotation of the earth, it presses to the westward along the coast of the United States, and gives that coldness to the water that modifies so materially the climate.

(2.) Another polar current sets from the north in the Atlantic Ocean near its eastern shore, and these two polar currents by their action on the Gulf Stream, deflect a part of its waters across the Atlantic and along the western coasts of Europe, to join again the equatorial current.

(3.) Part of the Lagullas current flows along the southwest coast of Africa towards St. Helena and Ascension, to join the equatorial current.

(4.) Another in the Pacific sets along the west coast of South America to join the westward flow from the Gallipagos.

westward in the southwardly flow in the northern hemisphere, is due to the same cause, viz. *inertia*, and the *difference of linear velocity* of points on the earth's surface, as the particles of matter of the currents reach successively different latitudes.

This may be illustrated by considering that a particle of matter at the equator moves with a linear velocity of about twenty five thousand miles in twenty four hours; and supposing this particle

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(5.) Another from the southward sets into the Indian Ocean near the coast of New Holland.

Very numerous currents depending on prevailing or periodical winds, like the monsoons, exercise much influence in particular parts of the oceans upon the currents mentioned.

The following references may aid those who wish to trace the state of present knowledge on the currents of the ocean and atmosphere.

De La Beche's Geological Manual, American edition, pp. 90—101. Purdy's Atlantic Memoir. Kotzebue's Voyages. Lyell's Principles of Geology, Vol. I. Lartigue, Description de la Cote du Pérou. Franklin's observations, Am. Phil. Transactions, Vol. II, p. 314. Blagden on heat of Gulf Stream, Phil. Trans. Royal Society, 1781, p. 334. Rennel on heat of Gulf Stream, Phil. Trans. Royal Society, 1793, Vol. LXXXIII. Wollaston on heat of Gulf Stream, Phil. Trans. Royal Society, 1824. Poronall's Hydraulic and Nautical Observations, quarto, London, 1787. Humboldt's Political Essay on New Spain, Vol. I, p. 53. Humboldt's Voyage to the Tropics, Vol. II. Young's Nat. Phil. Espy on Storms. Daniel's Meteorological Essays. Redfield, American Journal of Science, Vols. XXV and XLV. Maury, (Lt.) American Journal of Science, Vol. XLVII; Southern Literary Messenger, and Army and Navy Chronicle. Edinburgh Encyclopedia, Am. edition, Vol. X, pp. 158—159. Ed. Encyc., "Navigation," Vol. XIV, pp. 209—213. Ed. Encyc., "Phys. Geography," Vol. XV, p. 579. Ed. Encyc., "Hydrography of polar regions," Vol. XVI, p. 6.

The modes of observation by which the set and flow of currents have been determined, are deflective, and liable to error; it is desirable therefore, that accurate observations should be multiplied in every ocean, in every latitude and longitude, with a view to elicit truth. A knowledge of the set and flow of ocean currents, local as well as general, and the laws that govern them, is readily perceived to be of the highest importance to the interests of navigation, and to the whole world. Such knowledge can only be obtained by amassing a multitude of facts, systematizing them, grouping them, and finally generalizing from them. Individual effort cannot accomplish this. The aid, the influence, and the power of governments are necessary to cause the scattered rays of light to be brought to a focus. If an office be established under the direction of the Secretary of the Navy, where meteorological registers accurately kept on board all our national ships; records of the set and flow of currents observed on the same ships; the temperature of the waters of the ocean at the surface and at considerable depths, (also made daily when practicable,) and similar records from our merchant marine could be recorded, and occasionally published—and similar offices under the English, French, and other maritime governments, results may be obtained in a few years of great importance in navigation, and aid in deducing satisfactorily, the laws that regulate the currents of the atmosphere and of the ocean.

to be moving northward in one of the currents of the ocean or atmosphere, without having lost any of its linear velocity due to the motion of rotation of the earth at the equator, it will, when it shall have arrived at 60° north latidude, still move eastward at the rate of twenty five thousand miles in twenty four hours, which would at that latitude, carry it twice* as rapidly to the eastward as is due to the velocity of a point on that part of the earth's surface revolving around the axis of the earth. The resultant of these two forces, one tending to carry the particle to the north with a moderate velocity, and the other to the east with a velocity of five hundred miles per hour more rapidly than the surface of the earth moves at that latitude, would give a course nearly east. What is true of one particle, is true of the aggregate of particles of the currents of the atmosphere and of the ocean.

In the southern hemisphere the tendency of the currents *from* the tropics is towards the S. E., and those towards the tropics is to the N. W.

The causes of the currents under consideration will be admitted to be permanent. They must, from the operation of physical causes, have acted through all past time since the ocean has occupied its bed, and the earth revolved on its axis and circled around the sun, and they may be expected to continue to act through all future time. We may therefore reason upon the effects that may be supposed to have been produced by the action of these currents through long periods of past duration.

In the Final Geological Report of New York, I have shown† that the contour and relative relief of the country at, and immediately preceding the drift and quaternary epochs, while most of the present land of the United States was beneath the level of the sea, was in the main the same as now, and that the land was elevated in mass, with little relative change of position. The same may be shown to have been true at preceding epochs, with

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* Let γ and γ' represent the distances from the axis of rotation, R the radius of the sphere, and l the latitude. $\gamma : \gamma' :: \mathrm{R} : \cos. l \therefore \mathrm{R}\gamma' = \gamma \cos. l$, but $\cos. 60° = \frac{1}{2}\mathrm{R} \therefore \gamma' = \frac{1}{2}\gamma$; $\therefore$ as the circumferences of circles are proportional to their radii, the motion of a point on a sphere at 60° from the equator would be half the velocity of a point on the equator revolving around the axis of the equator.

† Natural History of New York, Part IV, Geology of First District, by W. W. Mather, pp. 152–154, 629.

some comparatively local exceptions.* This is not mere hypothesis. The evidences will be adduced in the discussion of the causes and periods of elevation of the land and mountains.

The primary ranges of rocks and mountains of the Atlantic states, those of northern New York and north of the great lakes, and those of the Rocky Mountains and Cordilleras of Mexico, existed in the same relative position as now before the deposition of the *newer* sedimentary rocks of the United States.† Similar primary ranges in South America give form also to its coasts.

We will here withdraw our attention from the great equilibrating currents of the ocean, and consider only that part of the compensating system of circulation that constitutes the equatorial current, the Gulf Stream and the Labrador current in the Atlantic Ocean. From the operation of dynamical causes already explained, the currents here alluded to, or others analogous to them in their directions and effects, may be supposed to have flowed during long periods, when the largest portion of the American continent was beneath the level of the sea.

The equatorial current in its westward flow, may be supposed to have been deflected by the primary ranges of the coast of South America, (or at least by the Andes,) in part to the southward over the vast pampas, but mostly to the northward through the Caribbean Sea, the Gulf of Mexico, and over the broad valleys of the Mississippi and St. Lawrence, which were then parts of the ocean.

As the direction of the equatorial current before its obstruction was to the west, if deflected by the eastern coast of South America, its course was then as now to the N. W., as above mentioned; but bending around more and more to the N., N. E. and E. as it progressed into higher and higher latitudes, in consequence of the dynamical law already explained. This current flowing to the W., N. W., N. and N. E., would progress by the base of the Cordilleras to the N. and N. E. towards Hudson's Bay; another part deflected still more to the east by the primary range in Arkansas and Missouri, and by meeting the polar current from the north through the Mississippi valley,‡ seems to have flowed

* The Green Mountains, Highlands, the Apalachian chain, &c., large in themselves, but local when we consider the vast expanse of undisturbed rocks.

† The evidence of this, is their unconformability.

‡ The evidence of the transport by such currents in this direction, is found in the transported materials of various degrees of coarseness in Mississippi, Alabama, and Louisiana, &c.

over the territory occupied by Missouri, Iowa, Illinois, Indiana, Michigan, Ohio, and Upper Canada, and thence eastward over Lower Canada and New York through the St. Lawrence and Mohawk valleys. The branch through the Mohawk valley would be deflected more to the E. and S. E. by the polar current through the Champlain and Hudson valley,* and again to the S. and S. W. by the Green Mountains and Highland ranges. A circular flow would thus be induced, and nearly all the materials transported by the equatorial current, from whatever sources they had been derived, may be supposed to have been deposited within this great eddy. These currents, as consequences of known dynamical laws, must have flowed in the way indicated from the period of the elevation of the primary ranges, until the continent was raised above the level of the ocean.

We know also that marine currents are constantly transporting earthy and organic materials, depositing them at places more or less remote from their origin, and that they now circulate over vast areas of the ocean.

It is believed therefore, that the ocean currents offer a satisfactory explanation of the transportation and deposition of the immense mass of the sedimentary rocks between the primary ranges north of the great lakes and the Gulf of Mexico, and between the Blue Ridge and the Rocky Mountains.

Other areas of similar rocks and connected with that described, occupy a part of Vermont, the southern part of Lower Canada, parts of New Brunswick, Nova Scotia, Maine, Massachusetts and Rhode Island. They are believed to be due to the same causes acting more extensively than we have considered them, in which the mountain regions of northeastern New York and of New England were islands. Even this is supposed to be but a limited view of the effects of these currents in the northern hemisphere, and the similar rocks of Europe may have been due to the same causes—the same currents. The uniformity of composition of the particular masses, whether thick or thin, their similar mineralogical

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* The evidence of a cold current from the north through the Champlain and Hudson valley, is treated of and believed to be established in the Geological Report of New York, by the author of this paper, in Part IV, Vol. I, pp. 150–154, 225, 293, 299, 274–275, 277–278, in 4to. Albany, 1843.

The subject of currents as aiding in the transport of materials, scoring of rocks, influence on organic life, and the evidences of their directions, are treated of under the quaternary, drift, and red sandstone formations in the same work.

characters over vast areas, the general similarity of organic contents not only on the American continent but even in Europe, indicate that the causes of these depositions and the conditions under which they were deposited from the ocean, acted with great uniformity over extensive portions of the earth's surface. The polar and equatorial currents are believed to be adequate for the production of the effects observed. Without farther explanation, the foregoing conclusion might be deemed unsupported by other evidence than probability.

In the final Report on the geology of the first district of New York, I have adduced the facts that first led to the observation of the directions of currents during the deposition of the sedimentary rocks. These facts when grouped, led from one generalization to another, until it was found that the cause was not confined to the United States or Europe, or even to the northern hemisphere, but in like manner affected the southern. The cause then was one affecting the earth. The great and permanent currents of the ocean, modified in direction and velocity by known physical laws, by the trend of coasts, and the contour of the former bed of the sea, were found to harmonize with the phenomena of depositions in the United States.

In the geological report above referred to, I have shown, (1st,) by means of the direction and distance of transport, that the distribution of bowlders and drift is such as would necessarily be the result, if such currents existed; and that the probabilities are that no other cause could have distributed them in a manner so peculiar.*

2. That the quaternary, composed of sands, clays, and loam, so extensive and uniform in composition and aspect, must have been owing to a cause as general as this.†

3. That the sand and gravel beds of the quaternary, so extensive in some parts of New York, are situated where conflicting currents must necessarily have met and formed eddies, if the country was beneath the level of the ocean.‡

4. That the distribution of organic life, (being extremely abundant in some parts, and as rare in the same continuous rocks

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* Natural History of New York, Part IV, Geology of 1st District, by W. W. Mather, pp. 197, 210–213, 217, 218, 222–228.

† Idem, pp. 129, 148–156.

‡ Idem, p. 148–150.

in others,) corresponds with the supposed position of the warm equatorial current and the cold polar flow, favorable to the development of animal and vegetable life in the one case, while in the other, few traces of organization have been preserved.*

5. The amount of deposition has been greatest where currents must have been obstructed by conflict with each other and had their velocities lessened, and where islands and irregularities of the bottom of the former ocean produced the same effect.†

6. The coal formations of the United States are situated where, from the contour of coasts, islands, and the bottom of the ocean, the grand eddies would necessarily be formed, and in which plants brought from the tropics or other sources would float and circle around until they sunk.‡

7. That the cretaceous and tertiary formations, as characterized by abundant remains of organic existence, extend little farther to the north than Sandy Hook, caused it is believed by the polar flow through the Hudson valley, having mixed with the warm Gulf Stream and cooled the waters too much to favor the development of organic life.§

8. That the red sandstone formation which extends from Carolina to Stony Point on the Hudson, and also believed to have been formed by the Gulf Stream, stops abruptly on the west shore of the Hudson River. The farther extension of the formation in that direction seems to have been cut off by the polar current flowing through the Champlain and Hudson valley, sweeping away the materials that were brought into it by the Gulf Stream.||

9. The fossil shells thus far found in the quaternary formation of the Champlain and Hudson valley are of an arctic character, corresponding to those of the Gulf of St. Lawrence, and those of Scotland, Denmark, Norway, and Sweden,¶ indicating with

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* Natural History of New York, Part IV, Geology of 1st District, by W. W. Mather, pp. 274–275, 277–278, 295–296, 299.

† Idem, pp. 129, 148–151, 223–225, 273–274, 289–293, 295–296, 299.

‡ Idem, pp. 275, 295–296.

§ Idem, pp. 150–151, 274–275, 299.

|| Idem, p. 293. The evidences of a polar current in this valley during the quaternary and drift epochs had already been adduced; those of more ancient times, during the deposition of the Silurian rocks, are subsequently adduced when treating of the rocks of the New York system.

¶ Idem, p. 278; also Annual Geol. Report of N. Y. 1841, p. 47, by Mr. Conrad.

much probability a current from the north. Other evidences of such a current have been observed.

10. The great coal formations of the eastern and central portions of the United States are based upon a sandstone which, at its outcrop on the *edges of the coal basins*, is a conglomerate or coarse sandstone, and sometimes a very coarse puddingstone, while towards the *centre* of the basin it is much finer. This fact indicates a stronger flow on the exterior of the coal formation than within its area. This is in strict conformity with the supposed origin of the coal formation—being formed in eddies, and that stronger currents immediately preceded the coal formation. Periods of comparative repose, with gently varying currents, preceded and succeeded the deposition of the conglomerate, and strata of slate, shale, sandstones, limestones, &c. were extensively and abundantly deposited.

11. The tertiary and upper secondary formations of the eastern and southern parts of the United States, and between the Mississippi River and the Rocky Mountains, may be attributed to the action of the Gulf Stream, and to a similar current on the western side of the Mississippi valley, before our continent was raised to its present level.*

Examples might be multiplied indefinitely in illustration, and much space would be required for a full development of the subjects of this paper. I have treated of general principles and masses of facts as connected with the physical geology of the sedimentary rocks of the United States, without going into details on local geology.

All that is known in relation to the sedimentary rocks of the United States, from the oldest transition to the quaternary formations, harmonizes, I believe, with the views here advocated of the causes of their transport, deposition, distribution, and organic contents; while on the other hand, I am not aware of any argument that can be urged in opposition to its probable truth.

We may therefore conclude, that the great masses of the sedimentary rocks of the United States have been deposited by marine currents before the continent fully emerged from the ocean.

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* Natural History of New York, Part IV, Geology of 1st District, by W. W. Mather, pp. 225, 274, 292.

Thus far we have considered the causes of the great equilibrating currents of the ocean; the physical laws regulating their circulation, and the influences of these currents on organic life, and on the deposition of the sedimentary strata. It remains to consider *whence* the materials of the sedimentary rocks have been derived, that have been transported by currents, and deposited over so vast an area and of such great thickness in the United States.

If the great currents of the ocean have flowed in times past as we have shown from physical causes they must be supposed to have flowed, the greatest proportion of transported earthy matter in the northern and eastern parts of the United States (except between the mountains and coast) must have been brought from the northward and spread to the south and southwest,—the general trend of transport according to the physical law that has been explained, tending to the southwest by means of the polar current. Other large quantities, together with tropical plants and animals transported by the equatorial current in its northwardly flow, would be spread over the areas occupied by the sedimentary rocks of the United States and British possessions, from the south to the north and northeast; and by the blending of the currents, and the deflections caused by this and by obstacles in particular parts, would be spread in various directions as we now find them.

Of the materials swept from the south and east by the equatorial current, we can have little direct evidence. This current sweeps, and has in times past swept over vast areas of the bed of the ocean, and along coasts and reefs of rocks, from which large quantities of detrital matter might, in the course of unnumbered ages, be supposed to have been swept away and transported to distant parts. Of the capacity of such a current to transport floating plants in ancient times to form our coal deposits, and the various traces of vegetation so common in all our sedimentary rocks below the coal formation, we have only to look at the effects of the present Gulf Stream, one branch of which carries large quantities of drift timber from the coasts of South America, the Gulf of Mexico, and the shores of the Atlantic, and lodges them on the shores of Labrador, Greenland, Iceland, Spitzbergen, Norway, and the Scottish islands;* and the other

* Lyell's Geology, Lond. edition, 1833, p. 251; Malte Brun's Geography, Part I, p. 112; Edinburgh Encyclopedia.

carries the gulf-weed and other floating bodies, and finally collects them in the centre of the great eddy of the Atlantic between the Cape de Verd, the Azores and Bahama Islands. This tract of the ocean has been known for more than three hundred and fifty years to be covered with such quantities of floating seaweed, plants, wood, &c. as frequently to impede the passage of ships. These floating bodies are supposed to circle around in this grand eddy (which is said to occupy a million of square miles, called the *grassy sea* and Sargasso sea) until they become water logged, loaded with marine shells, or decayed, and sink.*

The transport by the polar currents during the drift epoch is believed to be satisfactorily established; and it has been shown to be highly probable, perhaps almost certain, that the phenomena of the drift deposits are conformable to the action of the polar and equatorial currents. The phenomena of the transportation of the materials of the more ancient formations, have not been studied so attentively as to demonstrate the same sources and directions of transportation, but we may infer it as probable in a very high degree, that large quantities of earthy materials were transported by the flow of the polar currents over the barren and rocky regions in America, Europe, New Zealand, &c. where from the operation of physical causes the currents would flow from the poles towards the equator with a less depth and greater velocity than on other parts of the earth.† We may also infer it from the fact that the thicker masses of the coarser sedimentary rocks that are not calcareous, have been deposited in those parts where the polar currents in the United States must necessarily have flowed, when most of the continent was buried beneath the waters of the ocean. Those parts of the earth over which the polar currents are supposed to have flowed in ancient times, and from which they are supposed to have washed away the materials of the sedimentary rocks, are represented by all travellers as barren, unproductive, rocky and inhospitable wastes.

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* Natural History of New York, Part IV, Geology of 1st District, by W. W. Mather, pp. 295–296. Vide Lt. Maury's paper on ocean currents for a more full description; Army and Navy Chronicle, III, pp. 661–667; Southern Literary Messenger, Vol. X, No. 7, July, 1844; and American Journal of Science and Arts, Vol. XLVII, p. 161.

† The reasons for this supposition will be treated of in the discussion of the elevation of the continents above the ocean.

Heriot in his travels through the Canadas says of the vicinity of the river Moisa, north of the St. Lawrence—"No country can exhibit a more wild aspect than that which here extends on either side of the river. Stunted trees, *rocks* and sand, compose these inhospitable and desolate territories, which cannot boast of an acre capable of yielding any useful production."* The same traveller, speaking of the vicinity of Camarousca, says—"The sulphureous springs found here, and the immense masses of broken rocks, which appear to have been thrown together by some violent and uncommon effort of nature, afford grounds for supposing that this part of the country has undergone material changes."* Speaking of Newfoundland, near the harbor of St. Johns, he says—"It is bordered by dark and gloomy rocks, which exhibit a barren, inhospitable appearance; the country on a nearer view of its soil belies not the character of its rude uninteresting features, which amid their nakedness, display neither grandeur nor sublimity."†

Hearne, describing his journey to the Arctic sea, speaks of Marble Island, on which Messrs. Knight and Barlow were wrecked, and they and all their ship's crew perished, says—"Neither stick nor stump was to be seen"—"the main land is little better, being a jumble of barren hills and rocks, destitute of every kind of herbage except moss"—"and the woods are several hundred miles from the sea-side."‡

Again he says—"With regard to that part of my instructions which directs me to observe the nature of the soil, it may be observed that during the whole time of my absence from the fort, I was invariably confined to stony hills and barren plains all the summer."§

In latitude 68° N. and longitude 119° W. of Greenwich, Hearne came to the Stony mountains, and he says—"No part of the world better deserves the name. On our first approaching these mountains, they appeared to be a confused heap of stones, utterly inaccessible to the foot of man." Again—"The face of the whole country from the 59th to the 68th deg. of north latitude—between Hudson's Bay on the east, and the Athapusean Indian

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* Heriot's Travels, p. 70; also Hayden's Geological Essays, pp. 70–71.

† " " p. 38; " " " " " "

‡ Hearne's Introduction, p. 29.

§ " " p. 18.

country on the west, is scarcely any thing but one solid mass of rocks and stones, and in most parts is hilly."*

McKenzie says—"There is hardly one foot of soil to be seen from one end of French river to the other, its banks consisting of hills of entire rock." "The coast of Turtle lake is the same, but lower." "The country has the appearance of having been overrun by fire, and consists in general of huge rocky hills."†

Speaking of the country north of Lake Superior, he says—"The face of the country offers a wild scene of huge hills and rocks separated by stony valleys, lakes and ponds."‡ After giving a general view of the country northeast of the lakes, he says—"Of this great tract more than half is represented as barren and broken, displaying a surface of rock, and fresh-water lakes, with a very scanty proportion of soil. Such is the whole coast of Labrador, and the land called East Main, to the west of the heights which divide the waters running into the river and the Gulf of St. Lawrence, from those flowing into Hudson's Bay."§

Captain Cook, seeking a northwest passage, says—"The appearance of the country (North America) in latitude 57° 3′ N., discovered little else than naked rocks."‖ Also—"The barren isles in latitude 59° N., are composed of naked rocks."¶

The various travellers over the country within the United States between Lake Superior and the sources of the Mississippi, over a great breadth of country, give the same general characters of a rocky, barren, hilly region, with numerous small lakes.**

The same general characters hold true of Norway, Sweden, Finland, Lapland and Iceland in the northern hemisphere; and of New Zealand, Patagonia, Sandwich Land, Graham's Land, &c., in the southern hemisphere.

We perceive from these and other descriptions of travellers and voyagers, that in those parts of the earth where the polar currents would have the greatest velocity and least depth,†† the

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* Hearne's Travels, p. 227.

† McKenzie's Travels, pp. 36, 37. Vide also Hayden, Geol. Essays, pp. 72, 73.

‡ McKenzie's Travels, p. 49.

§ McKenzie's Travels, p. 426.

‖ Cook's Voyoges, II, p. 186.

¶ Cook's Voyages, II, p. 193.

** Schoolcraft's Travels. Lieut. Allen's Report to Sec. of War, 1834, &c.

†† Vide p. 17 of this article.

surface of the earth is destitute of soil, and is formed of bare and almost naked rocks that show few traces of vegetation.

Although the quotations from travellers lack that accurate examination that is necessary to a determination whether the surfaces thus described have been exposed to the action of violent and long continued currents, yet they have their weight, when considered in connection with the effects of known physical causes, and render it more than probable that the currents under consideration have flowed from the polar regions towards the equator, and from the tropics towards the poles, when this continent was beneath the ocean, and that the matter of the vast deposit of the sedimentary rocks of the United States was washed away by these great equilibrating currents from the bed of the ocean, from reefs, islands and coasts, and finally deposited from suspension over the great area where we now find it exposed to observation.

(*To be continued.*)

Art. II.—*Account of some new Articles of Philosophical Apparatus;* by Prof. E. S. Snell, of Amherst College.

1. *Instruments for illustrating sea waves, and waves of sound.*

The idea of constructing apparatus for such purposes was first suggested to me by seeing a cut of Prof. Powell's machine for exhibiting plain, circular and elliptical polarization of light. The thought struck me that every species of wave motion might be produced mechanically, and that such visible representations might be advantageouly used in giving instruction. I formed the design, therefore, of providing myself with a series of instruments to illustrate the oscillatory* waves of the sea, the acoustic waves of the air, and the undulations of the luminiferous ether, both ordinary and polarized. For the two first, which presented the least difficulties, I soon devised and executed a simple and convenient mechanism; and the instruments have more than answered my expectations in their operation and in their value as means of instruction.

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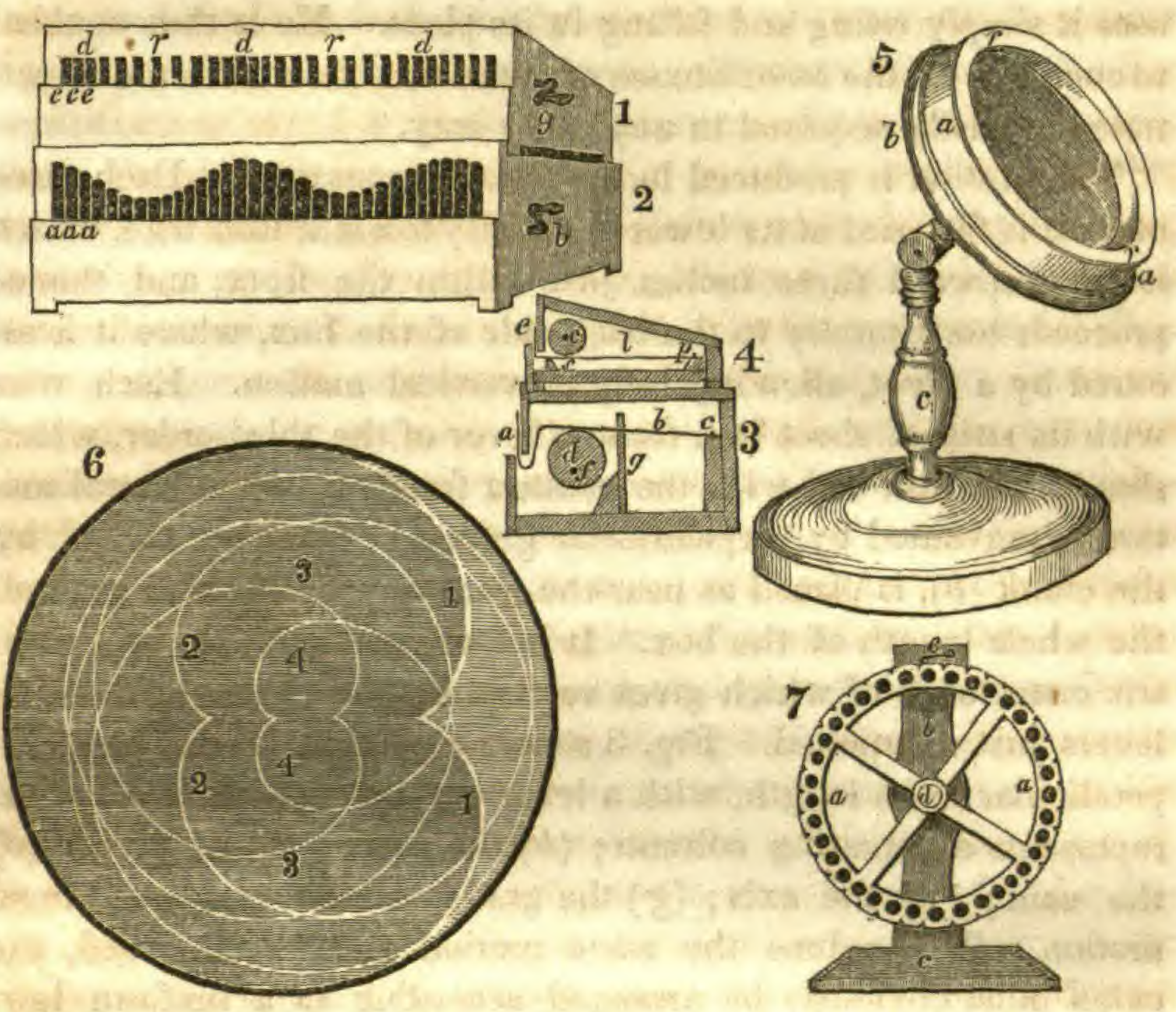
* See Russell's classification of waves, Reports of British Association, 1837, p. 425, and Vol. xxxviii, p. 100, of this Journal.



Figures 1 and 2 present a view of the two instruments as they stand connected in the philosophical cabinet. They are, however, entirely distinct, and the upper one may be removed from the lower, and either of them taken into the lecture room by itself. Fig. 2 exhibits the movements of sea waves. The box containing the mechanism is about two feet long, one foot wide and seven inches high. The lower half of the front projects beyond the upper half, so as to leave a space one fourth of an inch wide, in which the iron pieces (*a a*) rise and fall. There are thirty pieces of sheet iron, marked (*a a*), three fourths of an inch wide and four inches high, standing as closely as possible without danger of contact. They are painted black, to appear in strong contrast with the white front, which forms the ground behind them. These represent columns of water, and by turning the crank are made to rise and fall in such order that the waves which they form advance regularly in one direction and pass off, while other waves form and succeed them perpetually. If an observer fixes his attention upon the form of the waves, he sees them roll along horizontally, like billows of the ocean; but the moment his attention is directed to a single column, he as plainly sees it simply rising and falling in its place. He is thus enabled to conceive of the co-existence of these two facts with a distinctness not easily acquired in any other way.

The motion is produced in the following manner. Each piece of iron is fastened at its lower extremity to a stiff iron wire, which is bent upward three inches just within the front, and thence proceeds horizontally to the back side of the box, where it is secured by a pivot, allowing only of vertical motion. Each wire with its strip of sheet iron forms a lever of the third order, which should rise and fall with the greatest freedom, while lateral motion is prevented by perpendicular guides. The axis, turned by the crank (*b*), is placed as near the front as possible, and extends the whole length of the box. It is furnished with thirty excentric cams, each of which gives vertical motion to one of the wire levers just mentioned. Fig. 3 shows a section of the box, perpendicular to its length, with a lever and its supporting cam; (*a*) represents a vibrating column; (*b*) the lever; (*c*) its pivot; (*d*) the cam; (*f*) the axis; (*g*) the guide, which prevents lateral motion. To produce the wave motion already described, the cams must obviously be arranged according to a uniform law, the summit of the second being turned a given number of degrees farther round on the axis than that of the first, the third than the second, and so on through the whole. The axis with its entire series of cams will thus have the form of a helix. The exhibition of the instrument is most satisfactorily made, by presenting it first in a room partially darkened, so that the intervals between the columns are invisible. On turning the crank the illusion is complete—a liquid, or at least something flexible, is seen to roll in dark horizontal waves, and no other motion is dreamed of. But on admitting the light it is immediately apparent that every moving particle oscillates in a perpendicular direction, and has no other motion whatever.

Fig. 1 represents the instrument designed to illustrate acoustic waves. These are waves of condensation and rarefaction; and the molecular vibrations are made in the line of wave motion, and not perpendicular to it, as in sea waves, which may be termed waves of elevation and depression. The box is of the same length as the other; its breadth and height are a little less. The front is constructed in the manner already described. Thirty slips of japanned sheet iron (*e e*), one and a half inch long and three eighths of an inch wide, project upward nearly their whole length between the two front boards. These slips are taken to represent a series of atmospheric particles. It may be supposed that a line of balls, supported on slender white wires, would be a more appropriate representation. This was tried, but found not to make a sufficiently distinct impression of waves. A broad band rather than a delicate line needs to be seen in motion. The points of greatest condensation are at (*d*, *d*, *d*); and those of greatest rarefaction at (*r*, *r*). As the crank is turned, the waves of condensation and rarefaction advance regularly in one direction, constantly succeeded by similar waves, that are every moment forming themselves anew. It is more difficult in this case than in the former to render the molecular vibrations invisible, and to fasten the observer's attention wholly upon the waves. This effect is best accomplished by employing oblique vision. Let the observer look directly at some object about two feet above or below, while his attention is still directed to the instrument, and he will, without much distraction from the motions of the individual parts, receive an impression of dark waves travelling over the length of the box in regular and constant succession. Then, on turning the eyes upon the machine, each molecule is readily seen vibrating back and forth in the line in which the waves are running. A similar formation of condensed waves occurs in the legs of the centipede when walking.

The operation of this instrument is less interesting to the casual observer than the other; but in the hands of the lecturer it is far more valuable to the pupil, because the subject to be illustrated is not so easily understood. But here, as in the other case, a glance of a few moments will give one a clearer conception of the manner in which a minute vibration of every particle of a substance in regular order, I will not say *occasions*, but *is the same as* a succession of waves advancing through it, than can be obtained in many hours by means of verbal description. Indeed, I believe many individuals, by witnessing this experiment, soon comprehend the circumstances of a phenomenon, of which they would never have formed a distinct conception without such aid.

The several pieces of iron (*e e*) receive their motions from a cylinder three inches in diameter, running lengthwise through the box near its front, and turned by the crank (*g*). The surface of the cylinder is cut by thirty grooves, three sixteenths of an inch wide and of about the same depth. Each groove lies in a plane cutting the cylinder obliquely, and is of course an ellipse. But the several planes are not parallel. The second groove is revolved on the cylinder a certain number of degrees from parallelism with the first, the third holds the same relation to the second, and so of all the rest. The slips of iron (*e e*) at their lower extremities are firmly attached to as many horizontal levers, which extend to the back side of the box, where they are confined by vertical pivots allowing free motion horizontally, but in no other direction. Each lever, passing just beneath the cylinder, is furnished with a short smooth iron pin projecting upward, which runs freely in one of the oblique grooves, and thus receives a horizontal oscillatory motion. The ends of the levers near the front are supported on a soft smooth edge, made by stretching morocco leather over a thin metallic plate, which extends through the length of the box. By this means the levers move silently and with little friction. Fig. 4 presents a cross section of the box; (*e*) is one of the vibrating pieces; (*l*) the lever to which it is attached; (*p*) the pivot; (*s*) the leather edged support; (*c*) the grooved cylinder.

The fore-mentioned arrangement of the grooves causes the vibrating pieces to arrive at a given phase of their oscillations in regular succession. The same remark might be made of the cams and iron columns in the other machine. Indeed, this regular gradation of all possible phases, both in successive particles at the same time, and in the same particle in successive times, is the essential condition imposed on the vibrations of every conceivable kind of wave. It is a consequence of this condition that a wave always travels just its length during one vibration of any particle. This and all other relations that exist among the particles of an undulating medium, may be very satisfactorily presented to the eye by means of the instruments I have attempted to describe, or others of analogous construction.

2. *Instrument to exhibit caustics by reflection.*

The lecturer on optics, in illustrating the focal aberration occasioned by spherical mirrors, wishes to show the caustic curves as produced by reflection. He can indeed easily refer to examples; since these curves are sometimes distinctly formed by a horizontal light on a white cloth beneath an inverted tumbler, and on the surface of milk or other white opake substance in a circular vessel. These, however, are inconvenient modes of experimenting for the lecture room. A watch-spring, bent into a circular form and laid on white paper, serves a better purpose. But I have recently furnished myself with an instrument which presents the phenomenon in its greatest beauty; and not only so, but by successive reflections produces caustics of several orders in the most perfect manner. I regard this little instrument as an important addition to our optical apparatus, and think it may not be unworthy of description in a public journal.

I procured a steel ring, whose internal diameter was three and a half inches, made by bending and thoroughly welding a square half inch bar. Of course its external diameter was four and a half inches. A much less thickness between the inner and outer circumferences would, however, be sufficient. The interior was then turned in a lathe to as perfect a cylindric surface as possible, and highly polished. This is the essential part of the instrument; but for convenient use it is mounted in the following manner. The steel ring (*r*, *r*), fig. 5, is enclosed in a ring of sheet-brass (*a a*), and by it secured to a disk of wood (*b*), from the back of which projects a brass stem; and this stem is united by a tight hinge-joint to the top of the brass pillar (*c*). The whole stands firm on a heavy base of suitable size, as represented in the figure. The space within the ring is covered with smooth white paper, pasted down on the wood, so as to be perfectly plane. By turning the base horizontally, and the hinge vertically, the face of the ring may be brought into any desired inclination with a sun-beam admitted into a dark room. At a certain inclination, the light reflected from one half of the cylindric mirror will be thrown down strongly upon the paper, forming the ordinary caustic curves, but far more delicate and true than I have ever seen them in any other mode of experimenting. These are marked (1, 1) in fig. 6. If the plane of the ring be less inclined to the beam, the rays will pass across to the opposite half, and after a second reflection fall upon the paper in caustics of the second order, marked (2, 2). A still further diminution of inclination will reveal the third order (3, 3); and in favorable circumstances I have seen the fourth (4, 4), very faintly and delicately traced. The general form of these figures is the same, but the size diminishes from the first order through all the higher ones; the position also is every time reversed, since the cusp is necessarily turned away from the surface which produces the last reflection. It should be remarked, that all the orders are never in full view at once, as represented in the figure. When the first is most distinctly formed, no others are to be seen; and generally, when the caustic of either order is brightest, the higher orders are not formed at all, and the lower ones only in part. The caustics of the first order extend only half round the mirror, and are terminated by it in opposite points; but in all the others the two branches intersect, and may be traced round much more than the entire circumference. In proper positions of the instrument, the branches of many successive figures are seen, crowding closely upon the mirror, and upon each other, nearly parallel, and of exquisite delicacy. A pleasing and instructive experiment is performed by placing a pin perpendicularly upon the paper, and moving it back and forth. Its several shadows run along the curves as tangents, and reveal at once, for each point, the direction of the rays employed in forming it.

3. *Apparatus for experiments on inflection and interference of light.*

There is one class of experiments on inflection and interference, which, if the instructor in optics attempts to show them to his pupils, must necessarily consume much time. I refer to those in which are employed a metallic screen with minute apertures, and a magnifier, through which the light, having suffered inflection by passing the apertures, falls into the eye of the observer beyond. If any considerable variety of combinations is interposed for acting on the light, much trouble is experienced and much time wasted in exchanging one pattern for another. The article I am about to describe is merely a simple contrivance for reducing the time and labor of exhibiting this beautiful class of optical phenomena.

In fig. 7, (*a*, *a*) represents a wooden ring one foot in diameter, one inch and a half wide and one fourth of an inch thick, strengthened by two pieces of the same width and thickness, crossing each other perpendicularly in the centre. (*b*) is an upright flat pillar fastened to the heavy base (*c*), and having a height a little greater than the diameter of the ring. A short axis (*d*) is firmly attached to the middle of this pillar, on which the ring is confined by a nut, and turns with some friction. Thirty six holes, half an inch in diameter, are bored through the ring, having their centres carefully arranged in a circumference concentric with the axis. Another hole of the same size is made near the top of the pillar, with which each one in the ring comes in range, as it is turned. The plates of punctured lead, and other inflecting objects, are placed upon the apertures in the ring, being let into the surface of the wood by shallow dove-tailed recesses, or fastened in any other convenient way. A light spring (*e*) falls into a notch in the edge of the ring, whenever the aperture of the pillar coincides with one of those in the ring, as the latter is turned on its axis. The hole in the pillar being once adjusted in the line with the magnifier and the focus of light, the ring may be turned as fast as the experimenter chooses; and the inflecting patterns will all come in succession to the proper place to be seen by the observer. The spring offers a slight check to the motion, as often as an aperture of the ring attains the right position.

The instrument here described is already furnished with about thirty varieties of inflecting objects. A large proportion of them are made of sheet lead, with punctures and slits variously combined. Other holes are occupied respectively with a net of fine wire, a piece of fine comb, screws of delicate thread, placed almost in contact, &c. A very fine effect is produced by two pieces of fine ivory comb, one fastened in the aperture and the other fixed in a revolving cap; the latter, as it is turned round, makes, in conjunction with the former, a net-work of all possible angles, while the picture seen through the magnifier every moment changes its pattern and its color in the most pleasing and wonderful manner.

Art. III.—*Review of* Dr. C. T. Jackson's *Final Report on the Geology and Mineralogy of the State of New Hampshire.*

(Read before the Boston Society of Natural History, by Thomas T. Bouvé, March 5th, 1845.)

The survey of the State of New Hampshire was made under an act passed by its legislature during the session of 1839.

In September of that year, Dr. Jackson received his commission as State geologist, and he commenced his duties under it on the first of the following June, 1840. By the terms of his engagement he was expected to complete the survey in three years; and it was understood of each year, four months should be devoted to field operations and four to the analysis of minerals. This would of course leave four months for the less active, though not less important duties appertaining to the survey—in reviewing the proceedings in the field, and in preparing maps, with such other documents as might be necessary in a final report—a sufficiently short time for the purpose. So extensive and laborious, however, were the operations of the laboratory, that these alone, we are informed, instead of taking only four months of the year, required nearly all the eight not allotted to the field; a fact which, in view of what was accomplished in this way, will hardly surprise any one at all aware of the time necessary for the accurate analysis of minerals. Notwithstanding this, Dr. Jackson seems by no means to have limited himself to the specified duties of his commission, arduous as they were; on the contrary, he has contributed largely of his observations upon the agriculture of the State, and has furnished numerous analyses of the soils, neither of which were required of him by the authority under which he acted.

In the introduction, so called, to the work, after some observations upon the utility of such surveys as the one authorized by the State, our author proceeds to give a general view of the various rock formations that compose the strata of the earth's crust and of the fossils that characterize a portion of them. In remarking upon the Silurian and Cambrian rocks of Murchison and Prof. Sedgwick, (the New York system of the New York geologists,) he takes occasion to object, and most justly, to the course adopted by some of introducing local names to define classes of rocks found in every quarter of the earth. It is much to be hoped that his views in this particular may generally prevail; whilst at the same time, it may be remarked that a numerical arrangement, for which he expresses a preference, might not be found wholly free from objection.

In the brief but comprehensive view given of the various formations of the earth's surface, those which are developed in the strata of New Hampshire have of course received particular attention. In this connection, we are informed that a great anticlinal axis of primary rocks exists in New Hampshire, the transition Cambrian series being found to rest upon them, both in Maine on the east and in Vermont on the west, dipping in opposite directions. Upon these last are found, at more distant points from the centre of the anticlinal axis, the Silurian fossiliferous rocks, containing similar organic remains. Thus says the report—" We find trilobites occur near Lubec in Maine, on the Tobique river in New Brunswick, and at Clements, Nova Scotia. And in New York, the same fossils abound not far from Albany, at Lockport and Trenton falls. Besides the trilobites, we observe also the same shells in the rocks of Maine, Nova Scotia and New York. This fact seems to indicate that the strata on the northeast and southwest sides of this axis belong to the same formation, and were deposited under similar circumstances, while the primary rocks may be regarded as an immense wedge which was driven up from below, separating or disrupting the formerly continuous mass of strata."

Of the later formations, limited deposits of the tertiary are mentioned as occurring near Portsmouth.

The introductory chapters close with some interesting observations upon the diluvium or drift epoch, in which the theory of Agassiz is dwelt upon at some length, and facts are stated to show that however applicable it may be to some of the phenomena presented in the Alps, it is by no means so to those of New England. The grooves or scratches on the rocks, so common every where in New England, are stated by the author to be "better marked in Maine than in any other section of the United States," and that they there as elsewhere "cross the mountains with but little deflection, and run over extensive table lands where there could have been no slope for a glacier to move upon." The course of the general current, according to the observations of Dr. Jackson, in Maine, New Hampshire and Rhode Island, was from north 15° west to south 15° east, as shown not only by the scratches, but by the rock masses which have been borne from their original locations and deposited in a southeast direction upon other rocks. In view of all that is known of the movement of diluvium in this country, we cannot but regard the glacial theory as wholly inadequate to produce the results met with, and we think with Dr. Jackson, "that the grooves on the rocks, if produced by glaciers, should radiate from our principal mountain ranges and should be more abundant in their immediate vicinity, while they would be wanting in the level country and on our extended table lands."

Thus much for the general introduction. As preliminary to the first annual report we have an account of the plan pursued in the survey, of which one may get an idea in a few words from the author.

"In order to effect a systematic examination of the geological structure of the State, it was necessary to lay down some regular plan of operations, and knowing from previous explorations of the neighboring States, that the stratiform rocks pursue a general northeast and southwest direction, I was enabled to lay down on the map of the State certain lines, along which our first surveys should extend; intending to prepare sectional views or profiles of the strata, and determine their axis of elevation and the limits of the unstratified rocks.

"If the course or trend of the strata was northeast and southwest, then a line running northwest and southeast would cut all the stratified rocks at right angles and exhibit the order of strata and their anticlinal axis, while a northeast and southwest line would exhibit their extent in a linear direction. By laying out our work in this manner, the strata would be divided into a series of triangles, which might be again subdivided, according to the minuteness of the surveys required. In some districts which were complicated and interesting these subdivisions were made; while in others they were not required, or the limited time allowed for the exploration of the State, would not admit of their completion."

While upon these preliminary remarks we will quote a paragraph more, which we should think would satisfy one pretty fully that geological surveying can hardly with justness be ranked among sedentary occupations.

"The general outline of our work will give some idea of the various duties which have been attended to in the survey, and no one will venture to regard them as unimportant. Travelling in a wagon and making frequent excursions on foot, we have always found our time fully occupied in explorations, and the actual number of miles we have journeyed in New Hampshire in three years, nearly equals the diameter of the globe. Most of the lines of our explorations have been measured barometrically, and certain points have been determined by astronomical observations and bearings from other places. The direction of every vein of metalliferous ore, or bed of limestone and soapstone, and the course of all the drift striæ on the rocks, have been taken by means of the compass, while the inclination or dip of all the stratified rocks was measured by the clinometer," &c.

To this succeeds a theory and description of the primary unstratified rocks, and some notice of the minerals contained in them.

We now come to the detailed account of the operations in the field during the three years of service. In these, as also the labors of the laboratory, Dr. Jackson was assisted by gentlemen who had been his pupils, and who appear to have faithfully and acceptably performed the duties assigned them. In this connection it is pleasant to be able to remark that the author in the work before us, as well as in others published by him, has exhibited a strong desire to accord to those from whom he has in any manner received aid, all that strict justice could require. From Messrs. Whitney and Williams, two of the assistants, we have reports upon a number of sections which Dr. Jackson gave to their charge, and among others one upon the northern corner of the State, of which they give the geology and topography. The account by them of their journey into this distant and comparatively little known portion of the State, and of their operations there, though far too brief, will not be read without interest. To it the lovers of the romantic and beautiful in nature will feel indebted for the notice given of the Dixville Notch, which they speak of as perhaps surpassing the famous Notch of the White Mountains, in picturesque grandeur.

Camel's Rump mountain, situated in the line of boundary that divides New Hampshire from Canada, and one of the highest elevations in the State next to those of the White Mountain range, was ascended by Messrs. Whitney and Williams, who from not being able to find any marks of former visitations, judged it the first ascent ever made by white men. Of the view presented from the summit they thus speak:—

"But although the ascent was difficult, we were amply repaid by the magnificent extent of the view which was displayed before us, as the veil of clouds gradually rolled away before the wind. In the north a series of high hills stretching beyond each other for five or ten miles, divide the waters flowing into the St. Lawrence from those of the Magalloway and Connecticut, beyond which as far as the eye could reach, lay the extended table lands of Canada, unbroken by any abrupt elevation; to the east, the lofty granite ranges of Maine, Mt. Bigelow and Mt. Abraham; farther south, the numerous large lakes near Umbagog and the Diamond Hills; while in the farthest distance were seen the lofty peaks of the White Mountains; and to the west lay the lakes and tributary streams of the Connecticut, and the rolling ranges of the Green Mountains."

We have thus particularly noticed the report by Messrs. Whitney and Williams upon the northern section of the State, because so little is generally known of the region it relates to. We are, however, not quite contented with the knowledge we obtain of it from their remarks. These are, so far as they go, interesting and instructive, but they do not embrace all that we would like to learn, and which only a more thorough survey can impart. That as much was accomplished by these gentlemen as was possible under the circumstances of the case is manifest, but we cannot but think time would have been well spent in giving this section of the State a more accurate examination than it received.

The interest in the part of the work under consideration is much enhanced to the reader by the character of some of the country described in it. In the section from Haverhill to the White Mountains, surveyed by Dr. Jackson in person with his assistants, we have an account of that portion of the State, which embraces the most wild and romantic scenery of our country,—the mountains themselves towering to the heavens, presenting a thousand views of surpassing grandeur and beauty,—the well known Notch of the White Mountains, so called, and that of Franconia,—the "flume" and the "basin" of the latter place,—the profile view of "the old man of the mountain," &c. &c., these are all embraced in this region, and have received proper notice from the ready pen of our author.

In the narrative of field operations, we have of course an account of the development of the various rocks in every portion of the State, and of the minerals imbedded in them, some of which latter were not before known to exist in New Hampshire, as for instance *tin* (which indeed has not been found in any quantity elsewhere in the United States) and chlorophyllite, a new species, first discovered in this country by Dr. Jackson at Unity, whilst engaged in the survey.

Of the localities of minerals we have a great number described in the reports upon the several towns visited. We will mention a few of the most interesting and important.

Acworth.—Here are found the immense beryls which have given the place celebrity wherever mineralogy has a votary. The largest of the crystals are upwards of a foot in diameter and eighteen inches in length; the smaller, however, as is generally the case, are the most perfect. The color of them is a light blue green, and they are of the variety generally known as the aqua-marine. Black tourmalines and soda feldspar also occur here.

Unity.—In this town is a spring strongly chalybeate, possessing tonic properties. Granular quartz, and copper and iron pyrites, both in sufficient quantity for exploration, are met with. In this place was discovered the mineral chlorophyllite before referred to. It occurs in the syenite rocks, not far from the copper mine.

Orford.—Here are quarried granite, limestone and talcose slate. In the latter rock, clove brown tourmalines are found in large crystals, some of which are more than two inches in diameter and six in length.

Haverhill.—Mica slate, including extensive beds of excellent limestone, granite of good quality, and hornblende slate, abound here. There have also been found veins of copper and iron pyrites, sulphurets of lead and zinc, native arsenic, arsenical pyrites, and large crystals of garnet in chlorite.

Lisbon.—Within the present limits of this town is found the well known magnetic iron ore which is worked in the Franconia furnaces near. It occurs in granite, and composes a vein from three and a half to four feet in width. It is now taken up from a depth of one hundred and forty four feet. Accompanying the ore are numerous minerals which may be easily procured, among others, deep red magnesian garnet, crystallized and granular epidote, hornblende, &c. In the mica slates of this town, beautifully crystallized staurotides and garnets are found in abundance.

Bartlett.—In this place inexhaustible quantities of iron ore occur, of a character suitable for the manufacture of the best iron or of steel, chiefly composed of the peroxide, combined with a small quantity of the protoxide and a little manganese. This ore is found upon Baldface Mountain, in granite, at an elevation of fourteen hundred feet above the waters of the Saco. A number of veins have been opened, one of which has a width in some parts of fifty-five feet.

Jackson.—This is the locality of the tin ore before noticed as having been discovered by Dr. Jackson. It is found on Eastman's hill, and occurs in veins (of which five have been discovered) accompanied by copper and arsenical pyrites, arseniate of iron, native copper, phosphate of iron, fluor spar and other minerals. Some of the crystals are hemitropic, similar to those which are frequently found in the ores of Europe. The largest vein measures in its widest part eight inches. The richest specimens of the ore in the narrow veins yield about seventy three per cent. by assay. It occurs both compact and crystallized, but there cannot probably be enough obtained from the veins yet discovered to make it profitable to work it.

Eaton.—There is a very valuable vein of the sulphurets of lead and zinc in this town, which has been wrought to some extent for lead. The vein is however mostly made up of the sulphuret of zinc, and is about six feet in width. Dr. Jackson expresses the opinion that it might be profitably worked, provided the zinc ore should be reduced with that of the lead. The former contains about sixty three per cent. of metallic zinc, the latter about eighty four per cent. of lead.

Francestown.—Soapstone of the richest quality exists here, and is extensively wrought for the markets of Boston and other places.

Amherst.—In this town is a bed of limestone in mica slate, associated with which are found some interesting minerals. Egeran in large crystals, some measuring four inches in length and two and a half in diameter, of a deep red brown color. They occur in right square prisms, with lateral and terminal edges and solid angles replaced. Large dodecahedral crystals of the cinnamon stone garnet are also abundant, both in the limestone and in quartz connected with it.

There are likewise found in granite, in this town, crystals of magnetic oxide of iron, from one to two inches in diameter, and from the soil fine crystals of amethystine quartz (some of which are four inches in diameter and eight inches in length) have been ploughed up.

Warren.—Valuable ores of copper and zinc exist in this town, the former of which have been wrought to some extent. The copper ore is mostly pyrites, the zinc ore is the black blende, and associated with them in some veins are tremolite, iron pyrites and rutile.

Before passing from the account of field operations, we may remark that several lithographic prints of some of the most interesting views in the State adorn its pages. These are "Dixville Notch," "Lake Winnipisseogee," "Flume at Franconia," "Slide at the Willey house" and "Monadnock Mountain." There are also several wood engravings of other scenery and of appearances presented by the strata in many places. The lithographic views are from sketches made by Mr. J. D. Whitney, Jr., and were drawn on stone by Mr. Charles Cook of Boston.

A considerable portion of the work is devoted to "economical geology," so called, and to "agricultural geology and chemistry." In these departments, perhaps it may be said without disparagement to others, that among those of our countrymen who have treated upon them, our author is of the highest authority. His thorough knowledge of analytical chemistry, and his acquaintance with the application of this knowledge to the arts, must make his observations of great service to such of those interested in the working of metals and other minerals, as also of those engaged in agriculture, who choose to take advantage of them.

Economical Geology.

Under this heading a description is given of the various mineral substances found in New Hampshire, that are or may be serviceable in the arts. We state them as follows:—

Granite, Syenite, Gneiss, Mica Slate, Talcose rock or *Soapstone, Granular Quartz, Milk Quartz* and *Limestone,* the uses of which are well known.

Novaculite, of which oil stones and hones are made.

Mica, used for lanterns, windows, &c.

Infusorial silica, serviceable as polishing powder, &c.

Moulding sand, for moulding purposes and making Bristol brick.

Clay, used for brick-making and pottery.

Calcareous Marl, for agricultural purposes.

Black Lead or *Graphite,* for pencils and founder's pots.

Of precious stones, such as are used in jewelry, there are found—

Beryls, Iolite, Garnets, Amethysts, Quartz crystals, (some of which latter contain acicular crystals of the red oxide of Titanium.)

Of those serviceable in making paints may be mentioned—

Red, Yellow and Brown Ochres, Manganese, Molybdena Ochre, Yellow Blende.

Of metals, we have an account of seventeen, without including the bases of earthy and saline minerals. They are: *Iron* found in great abundance, *Zinc,* of which some mines can be wrought, *Copper* in considerable quantities, *Lead, Tin, Antimony, Silver* in the antimony and lead ores, *Gold* in minute quantities, *Molydenum, Manganese, Chrome, Titanium, Cadmium, Cobalt, Arsenic, Tungsten* and *Uranium.* Of all these various substances full accounts are given of their localities, means of obtaining, and uses to which they can be applied.

Respecting limestone and its conversion into lime we have a detailed statement, which embraces an account of some of the most important beds, the manner and cost of working, description of kiln used, &c. &c. We have, too, the full analyses of ten varieties of the stone.

Metallurgy.—The pages on this branch of economical geology we would particularly notice, as being in our estimation the most important, in a practical point of view, that the report contains. They are filled with the most valuable information upon almost every point connected with the mining and working of the various metals that are made subservient to the use of man, and would be the means, could they be placed in the hands of those most interested, of saving to them thousands upon thousands of dollars yearly, that are sacrificed for the want of a little knowledge of the chemical principles that have so great an influence in their operations.

We know something of the ignorance often displayed in the working of the metals in this country, particularly in that of iron, and we know too that unfortunate results frequently happen therefrom, which a little knowledge of science might prevent. In the present state of the art of reducing metal from the ore, in some sections of the country, a single suggestion will sometimes accomplish wonders. We have known instances where a few words from one scientifically acquainted with the action of the earths upon the ore in a furnace, have led to a greatly increased yield, and this without additional expense. We therefore feel the importance of diffusing just such information as this article on Metallurgy gives. We have in it an account of the various ores in the State, the methods of reducing them to a metallic state, their analysis, their yield, the best fluxes for their reduction, the probable cost in particular cases, together with full descriptions of the best kinds of furnaces in use, and plates explanatory. We have likewise the expenses of transportation from the ore beds to the markets, and the value of the product in such markets. Important information too is furnished in relation to the working of mines abroad, and valuable hints thrown out upon the subject of working some ores in this country that have hitherto been neglected.

Agricultural Geology and Chemistry.

Our proposed limits will not permit of more than a very brief notice of this portion of the work under consideration. It contains an account of the origin and distribution of soils; of the origin of organic matters in soils; of peat and swamp muck; of the analysis of peat and the action of alkaline salts upon it; of the origin of saline matters in soils and plants, and of the relative proportion of starch, of oil and of gluten in grains. Remarks are made on the improvement of soils, and the uses in agriculture of salt, nitre, the phosphates and sulphates. Agricultural observations upon some of the best farms in the State are added, and much more matter in relation to the subject, which is well worth the attentive perusal of those interested.

In the appendix we have barometrical and thermometrical observations made in different parts of the State for the measurement of heights; also barometrical registers, with other matter more particularly interesting to the scientific, and annexed we have some sectional profile views of the rocks from point to point, with a geological map of the State.

In conclusion, we will express the hope that Dr. Jackson will at some not very future period, present us with a connected account of his observations, not only upon the geology of the States surveyed by him, but also upon that of the provinces north, as we are sure he might do this to much advantage, with but little additional labor in the field.

Art. IV.—*Description of some Artificial Mounds on Prairie Jefferson, Louisiana;* in a letter to the Editors, dated Trinity, La., January 19th, 1845, from Prof. C. G. Forshey.

In a letter I addressed you some months since,* I made some mention of many systems of large mounds found throughout this region of country, promising from time to time to give such descriptions as may prove interesting to the antiquarian, of any of these unrecorded monuments of departed races. In executing this promise, it will not be in my power to proceed with them in the order of their importance, but in such order as they may fall in my way, when I have leisure to make accurate surveys. Such accounts only are to be relied upon. Many are found in the fastnesses of forests rarely penetrated by those who write of these things, and are vaguely described from hearsay, or second-hand evidence.

Though we frequently find isolated mounds,† they are commonly found in groups, and occasionally constructed with such reference to each other as to indicate design. Not that the specific object is ever very manifest; but that their conformation indicates arrangement in a particular order. Probably no question has more successfully baffled inquiry among antiquarians, than the specific object of these extensive works, and I have no solution to offer, deeming it, as I do, much more important to give a faithful detail of their present appearance.

In this immediate vicinity there are extensive works, which I have frequently visited, but having made no accurate survey I forbear giving them more than a passing notice, until I shall have given them a careful survey, such as has enabled me to present you with the map and detailed account of the mounds in Prairie Jefferson. The Ouachita river and its western tributaries abound in similar monuments, all of inferior magnitude, however, to those in this vicinity. These have been described, yet imper-

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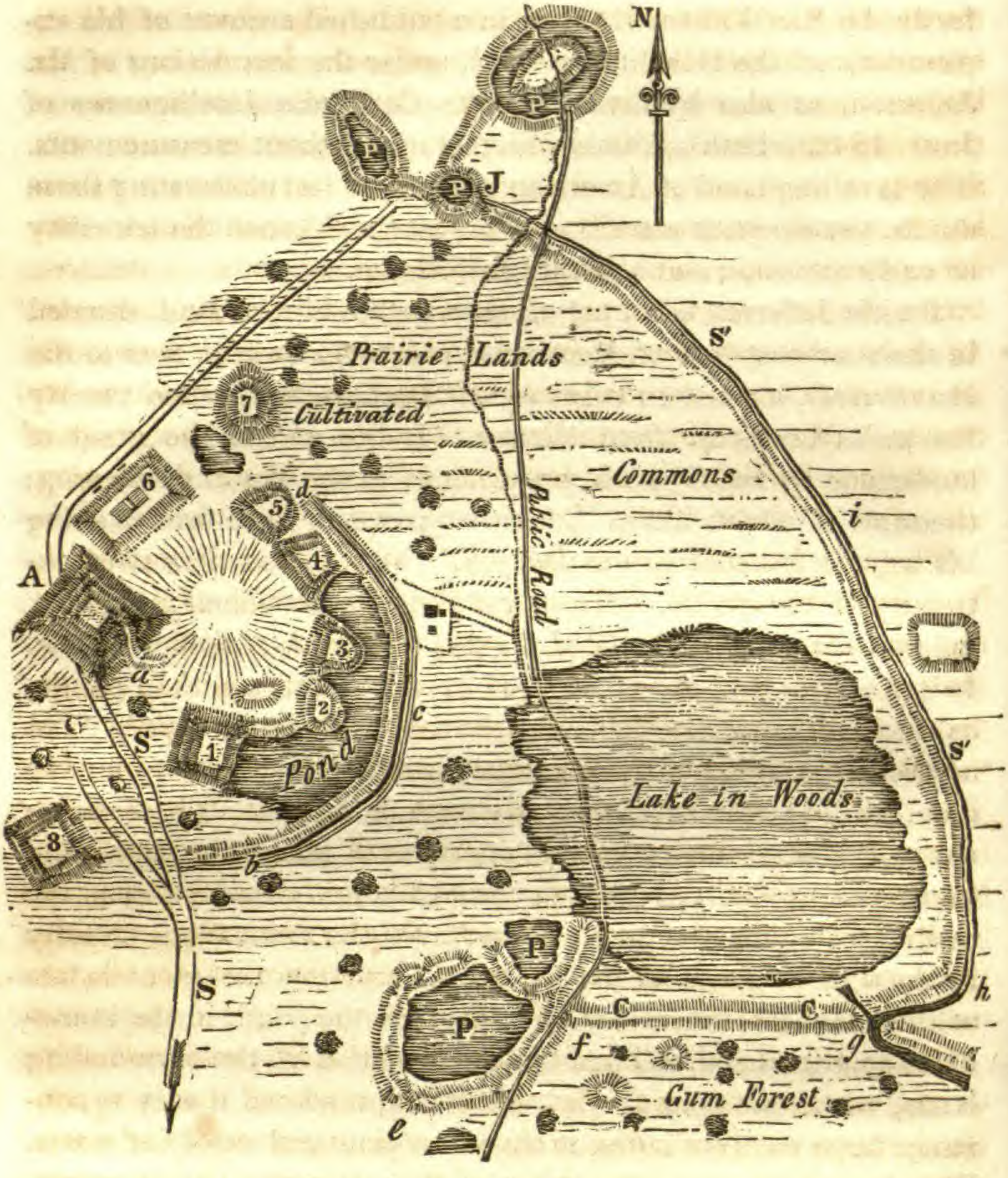
* An abstract of this letter may be seen in the close of this number.—*Eds.*

† The distinction of mounds into classes should not be forgotten. The tens of thousands of small, hemi-spheroidal tumuli noticed in my first letter, are rarely disposed with any reference to each other; whereas the angular, larger mounds, evidently of more recent construction, are much rarer, and generally arranged in groups, and sometimes with much system.

fectly, by Sir William Dunbar, in a published account of his explorations of the Ouachita in 1804, under the instructions of Mr. Jefferson, as also by myself in the Concordia Intelligencer of June, 1842. Both are from observations without measurements. The levelling hand of American industry is fast obliterating these dumb, yet eloquent records of the past; and hence the necessity of early attention and accurate description.

Prairie Jefferson is a tract of very fertile diluvial land, situated in the southeast part of Moorhouse parish, Louisiana, near to the Bœuff river, an eastern tributary of the Ouachita, some twenty five miles northeast from Monroe. It lies within the grant of land made by the Spanish government to the Baron de Bastrop; the same to which Aaron Burr is supposed to have been making his way, in his southern expedition. Near the southwestern extremity of the prairie, and partly in what is woodland at present, we find the works delineated in the topographic sketch below. It is probable that the whole area of the works was then prairie, as there are no forests that bear the mark of great antiquity; and as the whole diluvial surface must have been, at no very remote date, (geologically speaking,) destitute of forests. There are no streams of water nearer to this prairie than about five miles, and hence the necessity, with a dense population, of resorting to the making of artificial ponds. Accordingly the excavations, usually made without apparent design in constructing the mounds, are at this place so economized as to produce the ponds in the immediate neighborhood. Then the conformation of the surrounding lands, which are very gently undulating, rendered it easy to construct large ponds or lakes, to contain a perennial supply of water. This has plainly been the object of the extensive leveés, or embankments traced in the map. The general inclination of the land is southward, and the drains or wakes in the land, were with some skill called into aid. Generally, however, we find little to admire in the way of design or economy of labor.

The mound at A, termed "the Temple," from the supposition that it was the place of worship and sacrificial fires, is about fifty feet in height, with steep faces on every side, and accessible only by the causeway, which is a winding road on the southeast face, at "*a*." Its base covers a square of about fifty yards, and its summit, one of fifteen yards. All its angles are very much rounded, still it has the four faces very plainly marked. Since



DIMENSIONS OF THE MOUNDS.

		length in yds.	width in yds.	height in ft.
Temple (A),		45	60	48
Temple on summit,		17	15	—
No. 1, (summit,)		20	14	10
Causeway from 1 to 2,		45	4 base	3
No. 2, (summit,)	in rear,	20	14	12
	in front,	26		
No. 3, "	in rear,	13	17	12
	in front,	20		

		length in yds.	width in yds.	height in ft.
No. 4, (summit,)	in front,	20	18	7
	in rear,	20		
No. 5, "	in rear,	9		
	in front,	12	15	10
No. 6, "		70	25	5
No. 7, (base,)		44	44	4
No. 8, (summit,)		40	40	4
Causeway *b c d*,		350	2 to 4	1 to 3
Ditch *b c d*,		350	1 to 3	1 to 3

C, C. Causeway four feet high and forty feet base.—P. Ponds.—S, S. Natural swale.—S′, S′. Swale of regular channel, embanked inside in low grounds.

the clearing of the trees from it, several slides have marred its symmetry. From the summit a good view may be had of all the circumjacent works and country. The slides as well as excavations made in it, have developed its internal structure; viz. a series of strata or tables at about three feet distance, one above another, each surmounted by a pavement of rude bricks. No bones have been found in it; but the examination is avoided, from a desire to preserve the original symmetry of the Temple. All these principal mounds are so well known to have been used for places of burial by the builders,* that the fact ceases to be curious. Much credit is due to Dr. Harrison and H. Duval, Esq. for the care and taste they manifest in protecting and restoring the forms of the mounds.

The five mounds which face the Temple from the eastward, have great uniformity of figure and dimensions, being highest in the rear, excepting No. 1 and No. 5, which are nearly level on the top. Nos. 1, 2, 4 and 5 have terraces in front, and all incline gently to the plain, which has been somewhat excavated. In the rear, however, and chiefly on the sides, they are very abrupt. The pond in the rear is evidently artificial, and constructed by removing the earth for building purposes. Around them are a breastwork and ditch, (*b*, *c*, *d*), the latter produced by throwing up the earth for the former, probably to serve as a leveé around the pond to the high land at *b* and *d*. See the table for the dimensions of the several mounds.

Those which we have numbered 7 and 8, have great similarity in their magnitude, form and relative position to the Temple. But lying as they do in the midst of a cultivated field, their definite outlines are fast disappearing. No. 6, however, differs essentially from all the other mounds of the system. It is perfectly level on the surface, of gentle declivity and moderate height, (about five feet,) and has been fitly chosen as the site for a dwelling house and yard. The house fronts the area surrounded by the mounds, and the tasteful proprietors are about to improve the whole as ornamental grounds, with walks, shrubbery, flowers and grass, and thus protect them from deterioration.

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* Peruvian, Natchez and Choctaw crania are usually found, and with them are buried a variety of potter's ware, curious pipes, and beautifully finished stone hatchets, of various shapes and sizes.

The several ponds, it will be seen, have outlets for the water at particular points, which probably were controlled as the mound builders desired. The large embankment, (*e,f,g*), is abruptly cut off at *g*, and continued again towards *h*, diminishing in magnitude as the land grows higher, till it almost disappears at *i*. The swale continues up to very near the pond at J, but has no actual connection with it. It does not appear that the lake in the woods, within this leveé, has been produced by excavation. The smaller ones adjacent, however, are manifestly produced by throwing up the earth about them, as at *e,f*. The whole work, although exhibiting very little ingenuity, bears evidence of the vastness of the population, their industry, and not less certainly their ignorance and folly.

Art. V.—*Caricography;* by Prof. C. Dewey.

(Appendix, continued from Vol. XLVIII, p. 144.)

No. 184. Carex *Hoodii*, Boott. Tab. Ee, fig. 106.

Spica composita; spiculis 6–10, *distigmaticis* dense aggregatis ovatis superne staminiferis; fructibus ovatis lanceolatis plano-convexis ore obliquo bidentatis apicem subserratis, squamam lato-ovatam acutam subæquantibus.

Culm near two feet high, glabrous, acutely triquetrous, scabrous above, erect, leafy towards the base; leaves linear, narrow, scabrous on the edge, sheathing and long as the culm, with short leaves at the root; spikelets ovate, densely compacted into a head of half an inch or more long, close-fruited, staminate above, with a squarrose mucronate bract; stigmas two; fruit ovate, lanceolate, slightly serrate at the apex, bifid or two-toothed, with an ovate and acute tawny scale about equalling the fruit; light green.

Found by Douglas and Scouler on Columbia River, and named by Dr. F. Boott, secretary of the Linnæan Society, England, in honor of one of the intrepid men engaged in the Arctic exploring expeditions, and described in Hooker's Fl. Bor. Am. Vol. II.

No. 185. C. *Lyoni*, Boott. Tab. Ee, fig. 107.

Spica solitaria *tristigmatica* oblongo-lineari pauciflora superne staminifera; fructibus lanceolatis ore obliquis paucis sublaxifloris, squama ovato-oblonga subacuta paulo longioribus.

Culm 2–4 inches high, erect, slender, stiff and small, 3-sided, cespitose, leafy; leaves flat, narrow, nerved or striate, subsetaceous, rising towards the root, scabrous, sheathing, and much longer than the culm; spike single, short, linear, staminate above; stigmas three; fruit lanceolate, subscabrous; scale broad, ovate-lanceolate, submembranaceous on the edge and rather longer than the fruit; plant is light green, and has a stinted appearance.

Rocky Mountains, *Drummond*, and named and described by Dr. Boott like the preceding.

No. 186. C. *marcida*, Boott. Tab. Ee, fig. 108.

Spica composita oblonga densa basi bracteata; spiculis ovatis *distigmaticis* superne staminiferis stricte aggregatis; fructibus late ovatis lanceolatis supra convexis ore diviso cilio-serratis, squamam ovatam acutam subæquantibus.

Culm about two feet high, erect, stiff, triquetrous, rough on the upper part and leafy below; leaves lanceolate, flat, often involute on the edges, nerved, shorter than the culm; spike oblong, compounded of many small and ovate spikelets closely aggregated, and chiefly staminate towards the summit; stigmas two; fruit roundish-ovate, lanceolate, chiefly at the lower part of the spikelets; scale ovate acute, hyaline on the edges, about equal to the fruit; pale green.

Columbia River, *Scouler*, and named and described by Dr. Boott in Hooker's work with the two preceding.

No. 187. C. *Torreyi*, Tuckermani Enum. Tab. Ee, fig. 109.

Spicis distinctis; spica staminifera unica oblonga brevi-pedunculata; pistilliferis subbinis *tristigmaticis* brevi-oblongis subsessilibus pedunculatis erectis; fructibus *obovatis* glabris subtriquetris ore integro subrostratis perobtusis densifloris nervosis, squama acuta vix duplo longioribus.

Culm 12–18 inches high, erect, triquetrous, and with the subradical leaves pubescent; one oblong linear staminate spike with an oblong submucronate scale; pistillate spikes 2–3, oblong, nearly sessile, with leafy bracts; stigmas two; fruit oblong, *obovate*, tapering towards the base, dense; pistillate scale ovate, acute or submucronate, about half as long as the fruit; plant light green, and, the fruit excepted, pubescent.

Found near Carlton House, *Richardson*. Resembles C. *pallescens*, L. very much, but seems to be sufficiently removed from it. Mr. Tuckerman refers its locality also to the state of New York.

No. 188. C. *sphærostachya*, Dew.
C. *canescens*, L. var. *sphærostachya*, Tuck. Enum.
Tab. Ee, fig. 110.

Spiculis 3–5, ovatis subglobosis remotis sessilibus inferne staminiferis paucifloris (2–6) bracteatis; fructibus distigmaticis ovatis oblongis lanceolatis vel tereto-rostratis glabris, squamam ovatam hyalinam longioribus; culmis prostratis glabris.

Culm 1–2 feet high, slender, flaccid, subprostrate, leafy towards the root; leaves narrow and long; spikelets ovate, round or subglobose, remote, sessile, 2 to 6-flowered, staminate above, bracteate; stigmas two; fruit ovate, oblong, lanceolate or tapering-rostrate, longer than the white hyaline ovate scale; light green.

Wet plains—common.

This plant agrees with C. *gracilis*, Schk., which he afterwards united with C. *loliacea*, L. It is certain that the species here described, as well as C. *gracilis*, Schk., is far removed from C. *loliacea*, L. It is so different from C. *canescens*, that it deserves the name above given, as Schkuhr cancelled the other.

No. 189. C. *Sullivantii*, Boott. Tab. Ee, fig. 111.

Spicis distinctis; staminifera unica oblonga erecta pedunculata fructiferam vix superante; spicis pistilliferis ternis oblongis cylindraceis sublaxifloris bracteatis, inferiore longo-pedunculata et inferne distanti-flora; fructibus *tristigmaticis* ovatis acutis vel subrostratis bidentatis subtriquetris, squamam ovatam oblongam mucronatam subæquantibus.

Culm 16–24 inches high, erect, rather slender, triquetrous, scabrous above; leaves flat, linear-lanceolate, shorter than the culm, and shorter towards the base; staminate spike single, erect, cylindric, oblong, with oblong and obtuse scales; stigmas three; pistillate spikes three, oblong cylindric, not close-flowered, subdistant, bracteate, upper one subsessile, the lower long pedunculate and quite sparse-flowered below; fruit ovate, acute or subrostrate, bifid, subtriquetrous, about equalling the ovate obtuse or oblong obtuse and mucronate scale; light green.

Ohio, *Sullivant.*

No. 190. C. *chordorrhiza*, L. Schk. Tab. G, and Ii, fig. 31.

Spiculis 3–5, androgynis distigmaticis superne staminiferis in capitulo aggregatis ovatis sessilibus; fructibus ovatis acuminatis subrostratis superne convexis, squamam late-ovatam acutam æquantibus; culmis basi vel radici ramosis.

Culm a foot high, with rather short leaves, branching or sending up stems from the roots; spikelets 3–5, ovate, sessile, short, closely aggregated, with stamens at the apex; stigmas two; fruit ovate, acuminate, glabrous, convex above, equalling the broad-ovate acute scale; pale green.

Marshes, New York, *Gray* and *Sartwell;* Michigan, *Cooley.*

No. 191. C. *Liddoni*, Boott. Tab. Ff, fig. 112.

Spiculis 5–7, oblongo-ovatis arcte aggregatis ebracteatis inferne staminiferis; fructibus *distigmaticis* ovatis lanceolatis acuminatis ore obliquis glabris margine serrulatis, squama ovato-lanceolata acuta margine hyalina vix longioribus.

Culm 16–30 inches high, striate, scabrous above, leafy towards the base, and much longer than the flat linear lanceolate leaves, rough on the edges; stigmas two; spikelets staminate below, 5–7, closely aggregated; fruit ovate, lanceolate, acuminate, scabrous on the upper edges, scarcely longer than the ovate lanceolate scale, acute and hyaline on the border; scales and fruit rather chesnut brown; yellowish green.

Columbia River, *Scouler;* Michigan, *Cooley.* Named and described like No. 186.

No. 192. C. *rigida*, Good. Schk. Tab. U, fig. 71.

Spicis distinctis; staminifera unica, raro binis, oblongo-cylindracea, squama oblonga obtusa; pistilliferis binis vel ternis distigmaticis oblongis cylindraceis densifloris crassis approximatis brevibus latisque bracteatis, inferna brevi-pedunculata; fructibus ovatis subobtusis partim recurvis ore integris, squama oblonga obtusissima vix duplo longioribus; culmo brevi basin foliaceo.

Culm 3–8 inches high, erect, triquetrous, stiff, sometimes incurved, with short and stiff leaves at the base; stigmas two; pistillate spikes 2–3, sessile, oblong, short and thick, often with some staminate flowers at the apex, lowest subpedunculate with a bract longer than the culm; fruit ovate, obtusish, sometimes recurved, entire at the orifice, at first a little longer than the scale, and in maturity nearly twice the length of the oblong and very obtuse scale; glaucous green.

Ipswich, Essex Co., Mass., *Oakes;* long confounded with C. *cæspitosa*, L.

No. 193. C. *Steudelii*, Kth. Tab. Ff, fig. 113.

Spicis androgynis superne staminiferis paucifloris; fructibus 1–4 subglobosis vel ellipsoideis tristigmaticis teretibus unico rostratis binervosis ore obliquis, cum squama ovata acuta et inferiore foliacea margine scabra; culmis vel pedunculis subradicalibus nunc brevibus nunc perlongis.

Culm or subradical peduncles an inch to 6 or 8 inches long, triquetrous, scabrous on the edges, much shorter than the flat linear and radical leaves; staminate flowers several, with short and small ovate scale; stigmas three; fruit 1–4, globe-like or ellipsoidal, glabrous, tapering at both ends, and with a rostrum articulated to the body of the fruit; pistillate scales of very different lengths, ovate and acute, or long lanceolate and foliaceous; light green. Near maturity the articulated beak drops off, leaving the fruit obovate and very obtuse. Differs from C. *Willdenovii*, Schk. in its fruit; that being *oblong*, and this *spheroidal.*

Found in New York; Ohio, *Sullivant;* Kentucky, *Short;* also in Indiana.

No. 194. C. *Backii*, Boott. Tab. Ff, fig. 114.

Spicis androgynis superne staminiferis paucifloris; fructibus 2–4, *tristigmaticis* ovatis globosis conico-rostratis ore integris glabris binervosis maturo subpyriformibus; squama inferiore longo-foliacea lanceolata, superiore fructum subæquante et acuta.

Culm short, sometimes a few inches long, triquetrous, scabrous on edges, much shorter than the flat and subradical leaves; spikes staminate above, with few and small staminate flowers; stigmas three; fruit ovate and globose, with a conic beak articulated to the fruit, glabrous; pistillate scales of various length, the lower leaf-like and lanceolate, upper shorter, and highest about equal to the fruit and inclosing it; light green.

Arctic America, *Drummond* and *Richardson.* In the specimens from the Cumberland House, the plant was little cespitose. Named by Dr. Boott in honor of Capt. Back, so distinguished in the Arctic expeditions. Differs from the last two in its fruit and spike.

No. 195. C. *Hoppneri*, Boott. Tab. Ff, fig. 115.

Spicis distinctis; spica staminifera unica oblonga lineari, squamis oblongis obtusis instructa; pistilliferis binis *distigmaticis* brevi-ovatis sessilibus subdensifloris erectis; fructibus ellipsoideis subconvexis ore integris subapiculatis, squama ovata obtusissima submucronata longioribus.

Culm 3–6 inches high, slender, obtuse-triquetrous, shorter than the narrow and subinvolute leaves; pistillate spikes two, short-ovate and rather compact-fruited; stigmas two; fruit flat spheroidal, obtuse, and often with a slightly protruded apex, and longer than the ovate, and very obtuse scale; plant light green, but the iron or dark colored spikes and scales give it a sombre aspect.

Arctic America, *Drummond.* The specimens from Cumberland House have a stiff or rigid and *stinted* appearance. Named and described by Dr. Boott with the preceding, as before noticed.

No. 196. C. *riparia*, Gooden. Schk. Tab. Qq, and Rr, fig. 105.

Spicis staminiferis 2–4, oblong, cylindraceis nigricantibus, squama lanceolata instructis; pistilliferis 2–4, tristigmaticis, cylindraceis oblongis brevi-pedunculatis densifloris, fructibus rotundo-ovatis perbrevi rostro bifurcato contractis, squamam ovato-cuspidatam vel lanceolatam subæquantibus.

Culm two feet high, large, and with long leaves and bracts; staminate spikes many, large, oblong, thick, dark colored, sessile, with lanceolate scales; pistillate spikes 2–3, cylindric, long, sometimes with long and subrecurved peduncles and lax-flowered below, leafy-bracteate; stigmas three; fruit broad-ovate, oblong, contracted into a very short bifurcate beak, glabrous and dark colored; pistillate scale ovate cuspidate, scarcely equalling the fruit, or lanceolate equalling it; dark green.

Marshes; New England, New York, and Michigan; has been confounded with C. *lacustris*, Willd., with which it is often associated, from which it is easily distinguished by its fruit and scales.

No. 197. C. *monile*, Tuck. Enum.
C. *vesicaria*, var. *cylindracea*, Dew.
Tab. Ff, fig. 116.

Spicis staminiferis 2–4, longis, gracilibus, cylindraceis, squama longa lanceolata dotatis; pistilliferis binis cylindraceis longis sublaxifloris brevi-pedunculatis; fructibus ovatis longo-conicis subtriquetris inflatis rostro bifurcato glabris, squama oblongo-lanceolata plus duplo longioribus; culmo bipedali margine lævi, folia lineari-lanceolata superante.

Marshes—not common; fruit much longer than that of C. *vesicaria*, and its scale shorter.

No. 198. C. *Tuckermani*, Dew. Tab. Ff, fig. 117.

Spicis staminiferis binis vel ternis, cylindraceis sessilibus, inferiore brevi, squama oblonga subacuta instructis; pistilliferis binis vel ternis oblongis cylindraceis crassis pedunculatis subdensifloris; fructibus inflato-ovatis turgidis conico-rostratis bifurcatis glabris nervosis, squama ovato-lanceolata sub-duplo longioribus; culmo bipedali glabro erecto; bracteis foliisque planis longisque.

Wet meadows—common; confounded with C. *bullata*, Schk.; difference obvious; and the fruit and spikes separate it far from C. *monile*.

Var. *cylindracea*, Dew.
C. *cylindrica*, Schk.

Spicis et fructibus minoribus brevioribus; squamam ovatam acutam fructibus duplo superantibus.

Note.—The following species was described under the name of C. *aristata*, R. Br. As this name designates another plant, it becomes necessary to give to this a different name, and the following is adopted.

C. *mirata*, Dew. For description and figure, refer to Vol. xxviii, p. 240, of this Journal; Tab. V, fig. 67.

Along the shores of Lake Ontario, *Sartwell*, and in the state of Georgia, and in Arctic America.

Figures of the following species accompany this paper.

No. 184. C. *Hoodii*, Boott,	Tab. Ee,		fig. 106.
No. 185. C. *Lyoni*, Boott,	"	"	" 107.
No. 186. C. *marcida*, Boott,	"	"	" 108.
No. 187. C. *Torreyi*, Tuckerman,	"	"	" 109.
No. 188. C. *sphærostachya*, Dew.	"	"	" 110.
No. 189. C. *Sullivantii*, Boott,	"	"	" 111.
No. 191. C. *Liddoni*, Boott,	Tab. Ff,		" 112.
No. 193. C. *Steudelii*, Kunth,	"	"	" 113.
No. 194. C. *Backii*, Boott,	"	"	" 114.
No. 195. C. *Hoppneri*, Boott,	"	"	" 115.
No. 197. C. *monile*, Tuckerman,	"	"	" 116.
No. 198. C. *Tuckermani*, Dew.	"	"	" 117.

DEWEY'S CARICES, TAB. Ee.

Art. VI.—*Origin of the constituent and adventitious Minerals of Trap and the allied Rocks;* by James D. Dana.

(Read before the Association of American Geologists and Naturalists, May, 1845.)

In the remarks which I have the honor to submit to the Association at this time, it will be perceived that I pass over in part the same ground, and appeal in some instances to similar facts with those considered by Prof. Beck in his valuable memoir read two years ago at Albany. Without making myself his opponent, which position I would entirely disclaim, I have simply endeavored to hold up the subject in another point of view, hoping that the truth, with whomsoever it be, will the sooner claim its place among the facts of geological science. It will be remarked also, that the views presented bear closely upon those proposed by me at the session of this Association at Albany.

The minerals of trap and the allied rocks may be arranged in two groups.

1. Those essential to the constitution of the rock, or intimately disseminated through its texture.

2. Those which constitute nodules or occupy seams or cavities in these rocks.

Of the first group, are the several feldspars, with augite, hornblende, epidote, chrysolite, leucite, specular, magnetic and titanic iron; and occasionally Hauyne, sodalite, sphene, mica, quartz, garnet and pyrites. Of the second group are quartz, either crystallized or chalcedonic, the zeolites or hydrous silicates, Heulandite, Laumonite, stilbite, epistilbite, natrolite, scolecite, mesole, Thomsonite, Phillipsite, Brewsterite, harmotome, analcime, chabazite, dysclasite, pectolite, apophyllite, Prehnite, datholite, together with spathic iron, calc spar and chlorite. Native copper and native silver might be added to both groups, yet they belong more properly to the latter. To the same also might be added sulphur, and the various salts that are known to proceed from decompositions about active volcanoes, including the crystallizations of alum, gypsum, strontian, &c.; but these more properly form still a *third* group, and being well understood, will not come under consideration in the remarks which follow.

We observe with regard to the minerals of the first group, that they are all anhydrous—that is, contain no water. In this respect, the essential constituents of trap and basalt are like those of granite and syenite. But in the second group, consisting of the minerals occurring in cavities or seams, all contain water except pectolite, quartz, calc spar and spathic iron; and the last three are known to be always deposited in an *anhydrous* state from aqueous solutions.

We proceed to give a few brief hints with regard to the first group, intending only to glance at this branch of the subject, and then take up more at length the group of adventitious minerals.

Essential constituents of modern Plutonic rocks.—It is obvious that modern igneous rocks, although in some cases derived from the original material of the globe, have proceeded to a great extent from a simple fusion of rocks previously existing, and especially of the older igneous rocks. In accordance with this view, we may with reason infer that the trachytes and porphyries, which consist essentially of feldspar, have proceeded in many instances at least, from feldspathic granites; the basalts and trap from syenites, hornblende or augitic rocks.

A theory proposed by Von Buch supposes that the feldspathic rocks, as they are of less specific gravity, are from the earliest eruptions, or the more superficial fusings, while the heavier basalt has come from greater depths. Darwin thus accounts for the granites of the surface being intersected by basaltic dykes; the latter having originated from a deeper source, where their constituents took their place at some former period from their superior gravity. It virtually places hornblende rocks below feldspathic granites in the interior structure of our globe. The hypothesis is ingenious and demands consideration; but it may not be time to give it our full confidence.

But supposing these more modern rocks to have been derived from the more ancient granitic—what has become of the quartz and mica which occur so abundantly in the latter, while they are so uncommon in the former? By what changes have they disappeared?

In the fusion produced by internal fires, the elements are free to move and enter into any combinations that may be favored by their affinities. If silica, alumina, magnesia, lime, iron, the alkalies, potash and soda, were fused together—and these are the actual constituents of basalt—what result might we expect? From known facts, we should conclude that the silica would combine with the different bases, and these simple silicates would unite into more complex compounds. The silicates of alumina and the alkalies or lime, form thus one set of compounds, the feldspars; the silicates of magnesia and the isomorphous bases, iron and lime, another set, to which belong augite, hornblende and chrysolite; and if much iron is present, we might have with the lime and alumina, the mineral epidote. The experiments of Berthier, Mitscherlich, and Rose, and the facts observed among furnace slags, confirm what is here stated.

But not to go back to a resolution of the fused minerals into their elements, we may consider for a moment what changes the minerals themselves might more directly undergo in the process of fusion.

Much of the mica in granite, differs from feldspar in containing half the amount of silica in proportion to the bases—the bases in each being alumina and potash or soda. The change then in the conversion of the mica into feldspar, would require an addition of silica, which might be derived from the free quartz of granite. Other varieties of mica contain magnesia, which would go towards the formation of some mineral of the magnesian series. It is possible that trachytes and porphyry have thus been made from granite; but trap rocks could not have been so derived, as they contain from 10 to 25 per cent. less of silica.

Again, hornblende and augite are so nearly related, that they have been considered by Rose the same mineral, the different circumstances attending the cooling giving rise to the few peculiarities presented. There can be no difficulty therefore in deriving augite by fusion from hornblende rocks. This moreover has been actually confirmed by experiment.

Augite by giving up half of its silica, and receiving additional magnesia in place of its lime, is reduced to chrysolite.* The Gehlenite, nepheline, anorthite and meionite of Vesuvius, contain like scapolite, only 40 to 45 per cent. of silica and a large proportion of lime, and it is no improbable supposition, judging from the small amount of silica, and from the lime present, that scapolite rock, or rather limestones containing scapolite, may have contributed in part towards the lavas of that region. The ejections

* The formula of augite is $\dot{R}^3 \dddot{Si}^2$; that of chrysolite, $\dot{R}^3 \dddot{Si}$.

of unaltered granular limestones, and many mineral species pertaining to such beds, strongly support this view; and it is no less sustained by the fact, that in the Vesuvian basalts, Labradorite, which includes lime instead of the alkalies, replaces common feldspar. The original feldspar seems to have given way to leucite and Labradorite.*

An important source of new combinations is found in the sea-water which gains access to the fires of volcanoes. The decomposition which takes place eliminates muriatic acid, so often detected among volcanic vapors; but the soda and other fixed constituents remain, to enter into combination with some of the ingredients in fusion. Is not this one source of the soda forming the soda feldspar, or albite, and of the muriatic acid and soda in sodalite? Phosphates have been long known to occur occasionally in volcanic rocks, and lately phosphoric acid has been proved to be generally common in small quantities. Sea-water is also a very probable source of this ingredient, as has been shown by late analyses of the same by Dr. Jackson.

These few hints are barely sufficient to indicate something of the interest that attaches to this field of investigation, which the future developments of science will probably open fully to view. We do not attempt to explain why in these modern fusings, mica should not have remained mica, and the quartz still free uncombined quartz. The facts prove some peculiarity of condition attending the formation of the granitic rocks. Of this condition we know nothing certain, and can only suggest the common supposition of a higher heat and slower cooling, attending a greater pressure and different electrical conditions, and the same circumstances may have existed during the granites of different ages.

With these brief suggestions, I pass to the second division of the subject before us.

2. *Minerals occupying cavities and seams in amygdaloidal trap or basalt.*—These minerals have been attributed to a variety of sources, and even at the present time there are various opinions re-

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* Using $\bar{R}$ for the bases and Si for silica, the formula of leucite is $\bar{R}\,Si^{\frac{4}{3}}$; that of common feldspar, $\bar{R}\,Si^{2}$; that of Labradorite, $\bar{R}\,Si$. From this, it appears that feldspar may be reduced to leucite by giving up one third of its silica, the bases being the same in the two; and with this excess and other silica combining with the lime at hand, Labradorite might be formed.

specting their origin. According to some writers, they result from the process of segregation;—that is, a separation of part of the material of the containing rock during its cooling by the segregating powers of crystallization; and in illustration of the process we are pointed to the many segregations of feldspar, quartz, and mica, in granite and other rocks, the siliceous nodules in many sandstones, the pearlstones in trachytes and obsidian. Others have thought them foreign pebbles, enclosed at the time the rock was formed. Again, they are described as proceeding from the vapors which permeated the rock while still liquid, and which condensed as the rock cooled, in cavities produced by the vapors. By a few it is urged, admitting that the cavities are inflations by vapors like those of common lava, that they may have been filled either at the time the rock cooled or at some subsequent time, either by crystallization from vapors, or from infiltrating fluids, but more generally the latter.

Of these views we believe the last to accord best with the facts. Macculloch in his system of Geology—a work which anticipated many of the geological principles that have since become popular—dwells at length on this subject, and supports the opinion here adopted with various facts and arguments. Lyell also admits the same principles. A review of the facts will enable us to judge of its correctness.

1. In the first place, the cavities occupied by the nodules are in every respect similar to the common inflations or air bubbles in lava. These cavities are open and unoccupied in common lava, and may be no less frequently so in the ejections under water; and should they not be expected to fill in some instances by infiltration? They are the very places where an infiltrating fluid would deposit its sediment, or collect and crystallize if capable of crystallization; and such infiltrating fluids are known to permeate all rocks, even the most solid, and especially if beneath a body of water. It is evident, therefore, that we are supporting no strange or improbable hypothesis. On some volcanic shores one variety of the process may be seen in action. The cavities of a lava may be detected in the process of being filled with lime from the sea-water washing over dead shells or coral sand, and at times a perfect amygdaloid is formed. But the positions and characters of the minerals themselves establish clearly the view we support.

2. The mineral in these cavities sometimes only fills their lower half, as if deposited from a solution; and again, it incrusts the upper half or roof, as if solidified on infiltrating through. In the large geodes of chalcedony, stalactites depend from above like those of lime from the roof of caverns, and, as Macculloch states, the stalactite is often found to correspond to an inferior stalagmite, the fluid silica having dripped to the bottom and there become solid; moreover the superior pendent stalactite is sometimes found united with the stalagmite below. The same results are here observed as with lime stalactites in caverns, and often a similar laminated or banded structure, the result of deposition in successive layers. Such results can proceed only from a slow and quiet process,—a gradual infiltration of a solution from above into a ready formed cavity; they cannot be supposed to arise from ascending vapors, or gaseous emanations from below, no more than the stalactite in the limestone cavern.

Another fact is often observed. A geode of quartz crystals, sometimes amethystine,—in which every crystal is neatly and regularly formed, is found with the surface coated over with an incrustation of chalcedony, the part above hanging in small stalactites; and this chalcedonic coat sometimes scarcely adheres to the crystals it covers,—or is even loose and may be easily separated. There can scarcely be a doubt of a subsequent infiltration in a case of this nature.

We might rest our argument here, since the fact being ascertained with regard to quartz, it is necessarily established as a general principle with reference to the zeolites and other amygdaloidal minerals: for quartz or chalcedony, when present in these cavities, is, with rare exceptions, the *lower* or *outer mineral.* We find zeolites implanted on quartz, but very seldom quartz on zeolites. I have met with no instance of the latter, while the former is the usual mode of occurrence. Any deduction, therefore, respecting quartz, holds equally for the associated minerals.

How a cavity coated with a deposit of chalcedony can still be afterwards filled up with other minerals, has been deemed a mystery in science, but the possibility of it is now not doubted. Even flint and agate, as Macculloch states, are known to give passage to oil and sulphuric acid; and much more will this take place in the moist rocks before the agate has been hardened by exposure to the air. Silica remains in a gelatinous state for a long period after deposition, and in this condition is readily permeable by solutions. It is not necessary that the fluid which has acted the part of a solvent and filled the cavity, should yield place to another portion of fluid; for the process of crystallization having commenced, a new portion of the material is constantly drawn in to the same fluid, and the necessary chemical changes are also promoted by the inductive influence of the changes in progress —the catalytic action as it is called—one of the most efficient, and at the same time one of the most universal agencies in nature.

Other evidence with reference to amygdaloidal minerals is presented by the zeolites themselves.

3. The zeolites occupy veins or seams as well as cavities. Often the seams were opened by the contraction of the cooling rock, and at other times they were of more recent origin. In either case the minerals filling these seams must be subsequent in formation to the origin of the rock itself, and could not have proceeded from vapors attending the eruption. These seams sometimes open upward and can be seen to have no connection with the parts below, the rock in this portion being solid. Origin from above or from either side, is the only supposition in such cases.

Messrs. Jackson and Alger, in their valuable memoir on the geology of Nova Scotia, mention the occurrence of crystals of analcime attached to the extremity of a filament of copper, the copper having been the nucleus about which the solution crystallized, and state that their formation must have been subsequent to the formation of the rock.

4. Zeolites, moreover, have been found forming stalactites in basaltic caverns, as was observed by the writer in some of the Pacific islands; and Dr. Thomson has described and analyzed one (Antrimolite) from Antrim in Ireland near the Giant's Causeway.

These facts favor throughout the view we urge, that the amygdaloidal minerals have in general resulted from infiltration, and were not necessarily formed simultaneously with the erupted rock.

5. We remark farther, that no lavas have ever been shown to contain at the time of ejection, any of the zeolitic minerals. The zeolites of Vesuvius are known to occur only in the older lavas, and afford no evidence against our position. The cavities in lavas, as far as observed, are empty as they come from the volcanic fires, with the exception of those containing sparingly some metallic ores which are condensed within them. Considering

the fusibility of the zeolites and their easy destruction by heat and by volcanic gases, sulphureous and muriatic, we should *a priori* say that they could not be formed under such circumstances.

6. Besides, as we have stated, none of the proper constituents of trap or basalt—or the minerals disseminated through these rocks,—contain water. They are all anhydrous. The minerals formed accidentally in furnaces are anhydrous. The constituents of granite, syenite and porphyry are all anhydrous. It is only those minerals which are found in geodes or seams that contain water. Of equal importance is the fact, that none of the essential constituents of these rocks have ever been found in these geodes or cavities along with the zeolites, as might have been the case had they been formed together, by segregation or otherwise. Neither feldspar, although so abundant, nor augite, nor chrysolite, have been found filling, like zeolites, or with them, the cavities of amygdaloid. There is then a wide distinction between the anhydrous constituents of these rocks, and the hydrous zeolitic minerals.

A few zeolites have been found in granite or gneiss, but they are so disseminated that they can be shown to be of more modern origin than the rock, and to have resulted from some decompositions of true granitic minerals. They differ entirely in their mode of distribution from the feldspar, garnet, &c. of granite. Along with a decomposing feldspar, it is not unusual to find stilbite in the cavities formed by the decomposition.

Zeolites also have been found disseminated through the texture of basalt, clinkstone, &c., like the feldspar, augite, &c. But the proportion varies widely, and in some parts of the same bed they are found to be wanting; so that we have sufficient reason for classing these disseminated zeolites with those in the cavities, as formed or introduced by infiltration.

7. Bearing upon this subject, it should be observed, that the constituents of amygdaloidal minerals are, in general, those of the containing rock. Silica, potash, soda, alumina, are found in the feldspars; lime, magnesia and iron in augite or hornblende; iron and magnesia in chrysolite. These are all the constituents needed, except a little baryta for one species. The feldspar decomposes readily and gives up its ingredients, its potash or soda, silica and alumina; the same is true of augite and chrysolite, which afford magnesia, lime, silica and iron. With water to infiltrate, we

should therefore have all the necessary ingredients at hand for the required compounds. The fact already stated, that zeolites have been found as stalactites in caverns, seems to prove that they *do* actually result from decompositions and recompositions, such as have been supposed. Thus we have all the conditions at hand necessary for producing, by infiltration, the zeolites and the chlorite nodules of these rocks; the alumina, alkalies and lime, contribute, along with a portion of the silica, to the zeolites, and the magnesia, iron, and another portion of the silica, to the chlorite,* often as abundant as the former. The amygdaloidal nodules frequently have a green coating, which farther indicates the probable truth of these views; for it appears evidently to be a precipitate from the solution before a crystallization of the zeolites took place—a settling, perhaps, of the insoluble impurities taken up by the filtrating fluid in its passage through the rock, or of the formed chlorite, less soluble than the zeolites. Occasionally, when the rock contains copper, these nodules have an earthy coating of green carbonate of copper—the carbonate having proceeded, apparently, from the native copper of the rock, by the same process as explained.

The hypothesis of filtration seems, then, to be at least the principal source of these minerals. In some instances the filtrating fluid may have derived its ingredients from distant sources. The salts of sea-water may act an important part in these changes. Silica is dissolved on a grand scale during submarine eruptions, as we have elsewhere urged, and is thence distributed to the rocks around. Lime, also, is taken up in a similar manner. But the rock itself has often afforded the ingredients for the forming minerals, during the passage of the filtrating fluid through it. By the same means, the adjoining walls of a seam or dyke—which receive the drainings from the rock of the dyke—are often penetrated by zeolitic minerals.

It may be thought that I am giving undue influence to a favorite theory, and in the minds of some, these conclusions may be set down among mere speculations in science. But the circumstances attending submarine igneous action, I am persuaded, is not generally apprehended. What is the condition of the deep

* Chlorite consists of the same elements as augite or hornblende, except that the lime is excluded and water added. They are silica, alumina, magnesia, oxyd of iron, with 12 per cent. of water.

bed of an ocean? Even at a depth of three miles, the waters press upon the bottom with a force equivalent to a million of pounds to the square foot; and with such a forcing power above, can we set limits to the depth to which these sea waters—magnesia and soda solutions—will penetrate? Will not every cavern, every pore, far down, be filled under such an enormous pressure? Let a fissure open by an earthquake effort, and can we conceive of the tremendous violence with which the ocean will rush into the opened fissure? Let lava ascend, can we have an adequate idea of the effect of this conflict of fire and water? The rock rises, blown up with cavities like amygdaloid, and will a long interval elapse before every air cell will be occupied from the incumbent water? Suppose an Hawaii to be situated beneath the waves, pouring forth its torrents of liquid rock;—this island contains about five thousand square miles, which is less than the probable extent of many a region of submarine eruption; —suppose, I say, the fires were opened and active over an area of some thousands of square miles—are there no effects to be discovered of this action? There is no geologist that pretends to deny the premises—the fact of such submarine eruptions, the ocean's pressure, the effect of fire in heating water, and in giving it increased solvent power; and why should they not reason upon the admitted facts, and study out the necessary consequences? Surely, if there have been effects, we might expect to see some of them manifested in the cavities of the ejected rocks, which were opened at the time to receive the waters and any depositions they might be fitted under the circumstances to make.

We are led by these considerations to another point in connection with this subject: the probable condition under which the different amygdaloidal minerals have been formed. Have they all proceeded from heated solutions, or all from cold solutions? or can we distinguish some which are indubitably of one or the other mode of formation?

Bearing on these questions, we notice such facts as are afforded by the condition and relative positions of the minerals in geodes. And I would here acknowledge my obligations to the valuable memoir, before alluded to, by Messrs. Jackson and Alger. The paucity of information on this subject, to be found in the various accounts of similar rocks by other writers, is surprising. Even where special pains have been taken to describe the mineral species, the relative positions of the minerals is very seldom noted.

It has been altogether too common among geologists to treat mineral information with a degree of neglect almost amounting to contempt, although, as facts will probably hereafter show, they lie at the basis of an important branch of geological science.

But to proceed with the subject before us. We find that

Quartz or *chalcedony*, and *datholite*, very seldom overlie other mineral species in geodes or amygdaloidal cavities, while the latter often overlie them.*

Prehnite is usually lowermost with reference to all the species except the two just mentioned. Occasionally it is found upon analcime, as at the Kilpatrick hills.

Analcime is commonly situated below all, except quartz, datholite and Prehnite.

Of the remaining species, chabazite, stilbite, harmotome, Heulandite, scolecite, mesole, Laumonite and apophyllite, it is more difficult to distinguish an order of arrangement. My investigations only enable me to state that chabazite is usually covered by the rest, (when associated with them,) yet it is sometimes superimposed on stilbite; and apophyllite is almost uniformly above all with which it may be associated; calc spar is at different times above and below. We thus arrive at the following as the usual order of superposition.

1. Quartz.
2. Datholite.
3. Prehnite.
4. Analcime.
5. Chabazite, harmotome.
6. Stilbite, Heulandite, scolecite, natrolite, mesole, Laumonite, apophyllite.

It is a reasonable inference that the species which covers the bottom of a cavity was first deposited, and, as a general rule, that the others above were formed, either simultaneously, or in succession upon the lowermost, as their order may indicate. Each is usually perfect in its most delicate crystallizations, so that we can not suppose that the minerals first deposited often underwent change after their deposition, though instances of this may no doubt be detected.

It is also evident that if there were any species formed previous to the complete cooling of the rock, or if any require for their for-

* The writer has observed stilbite, apophyllite, calc spar and Prehnite overlying datholite, and various species over Prehnite.

mation an elevated temperature, they are those first deposited—the first in the above series. A few considerations will place this if possible in a clearer light.

Quartz, as we have stated in a preceding page, and fully remarked upon elsewhere, enters largely into solution during submarine eruptions. This solution has been shown, by actual experiment, to be a necessary consequence of such action. This fact corresponds most completely with the above deductions. Quartz usually forms the first lining of the geode or amygdaloidal cavity, when it is found at all, and, moreover, it is the most abundant of all amygdaloidal minerals.

Quartz may also proceed from decompositions of the rock in the cold, and incrustations of this kind are known to occur; but such an explanation does not account for its generally preceding all other species in filling cavities and seams in trap rocks, and is insufficient to produce the large deposits of silica, sometimes amounting to many tons in a single geode.

It should not be understood that the quartz is supposed to be derived always from the same heated waters that attended the formation of the containing rock; for later eruptions in the same region might, at a subsequent period, produce a like result: yet, as its place in the series proves it to be the earliest in formation, it has probably been generally deposited from the water heated during the eruption of the rock. Leaving quartz, we pass to the other minerals.

It is a striking fact that the minerals next to quartz in the table given—*datholite*, *Prehnite* and *analcime*—contain less water than either of the following species. While the others include from 10 to 20 per cent., the first, datholite, has but 5 per cent., Prehnite about 4½ per cent., and analcime 8 per cent.* This fact certainly leans towards the view of their having origi-

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* The following table shows the percentage of water, and gives at the same time a general view of the composition of the zeolites.

Silica, boracic acid, lime.—Datholite (5 Aq.)

Silica, alumina, lime.—Prehnite (4½ Aq.) Heulandite (14 Aq.) Scolecite (13½ Aq.) Epistilbite (14 Aq.) Stilbite (17 Aq.) Laumonite (17 Aq.)

Silica, alumina, lime and potash or soda.—Mesole (12 Aq.) Thomsonite (13 Aq.) Phillipsite (17 Aq.) Chabazite (21 Aq.)

Silica, alumina, and either soda, baryta or strontia.—Analcime (8 Aq.) Natrolite (9½ Aq.) Harmotome (15 Aq.) Brewsterite (13 Aq.)

Silica, lime and potash.—Apophyllite (16 Aq.)

Silica, lime.—Dysclasite (16½ Aq.)

nated at a somewhat more elevated temperature than the other species—the same conclusion that is drawn from their lower position in geodes.

The fact, also, that Prehnite has been found forming pseudomorphs, bears the same way; for heat would be necessary, in all probability, to aid in removing the original mineral. The vast extent of some Prehnite veins—occasionally, as Dr. Jackson has observed, three or four feet wide—refers to an origin like that of the quartz in similar rocks. Indeed, there seems little doubt that Prehnite is often derived from that portion of the silica in solution which entered into combinations at the time with the alumina and lime which the siliceous waters contained; and probably the lime as well as silica was derived in part from an external source. The pseudomorphs prove that Prehnite may have been the result also of subsequent eruptions, at the same time that they show the probable necessity of heat for its formation.

Datholite is a compound of silica, lime and boracic acid, with about 5 per cent. of water. Besides the small percentage of water, and its being, next to quartz, the lowermost mineral in geodes, we find an additional fact, alone almost decisive with regard to its origin, in its containing boracic acid. Boracic acid is often evolved about volcanoes or in volcanic regions. The hot lagoons of Tuscany, and the volcano of Lipari are the most noted examples.

Although boracic acid has never been detected in sea water, there can be little doubt of its occurring in it. The usual modes of analysis by evaporation would dissipate it, and of course it could not thus be detected except with special care and by operating on a large quantity of water. Borate of soda (boracite) is found only in beds of salt and gypsum,—both sea-water products. Moreover, borate of lime has been lately found on the dry plains in the northern part of Chili, along with common salt, iodic salts, gypsum and other marine salts, and all are so distributed over the arid country, that the region has been lately described as having been beyond doubt once the bed of the sea. These facts render it altogether probable that sea water which gains access to volcanic fires is the source of the boracic acid in volcanic regions.*

* The only other known source is the mineral tourmaline, quite an improbable one in the case before us. It is possible that tourmaline may have received its boracic acid from the sea during granitic eruptions, and the occurrence of this mineral in the vicinity of trap dykes is explained in the same manner.

If this be its origin, the necessity of heat and pressure must be admitted, in order to produce the chemical combinations in datholite. Its elements are not those of the feldspar or other trap minerals, like the zeolites superimposed on it; but they have come from an extraneous source, and none is more probable than the sea waters, which were heated at the submarine eruption, and permeated the bed of molten rock shortly after ejection. Thus placed in circumstances of pressure and confinement, along with silica in solution, the volatile boracic acid might enter into the combination presented in datholite.

An interesting fact bearing upon the history of datholite was observed by Dr. Jackson at Keweena Point, Lake Superior. The datholite is often formed there in veins with native copper, and is associated in some places with a curious slag of boro-silicate of iron and copper. Sometimes the crystals of datholite, as well as the Prehnite and calc spar, contain scales or filaments of native copper. These very important observations seem to establish the same origin for the three minerals—for Dr. Jackson states that they appear to be cotemporaneous—and if calc spar has been deposited from a solution, the same holds true of the others. They have all been formed subsequent to the copper filaments of the cavities, for they were deposited around them; yet may have been the next to form during the cooling of the rock. The boro-silicate of iron and copper has resulted from the same causes.

Analcime approaches the zeolites in composition, but like the Prehnite and datholite it contains less water, and is very different in its crystallization. We have less evidence as to the heat necessary for its formation; yet it was probably formed at a somewhat elevated temperature.

With regard to the other amygdaloidal minerals we are in still greater doubt as to the necessity of heat. We cannot at present fully appreciate the efficiency of chemical agents in a nascent state acting slowly without heat through long periods. Many of them may require heat, and some may be the last depositions from the filtrating waters after they have nearly or quite attained their reduced temperature. But the formation of zeolitic stalactites in caverns favors the view that some at least may form at the ordinary temperature by the slow decomposition of the containing rock after it had emerged from the waves.* Kersten has lately

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* Annales des Mines, ii, (4th Ser.) 465, 1842.

described a modern stellated zeolite forming incrustations on the pump-wells of the Himmelsfurth mine near Freyberg. It consisted of silica, oxyds of iron and manganese and water. Further examination will probably bring more of these modern products to light.*

The formation of particular minerals in certain regions, depends of course upon the supply of the necessary ingredients. Where the supply of lime has been large, we should expect to find some of the minerals, Prehnite, Heulandite, Laumonite, stilbite, scolecite, dysclasite, chabazite, for carbonate of lime decomposes the silicates of potash or soda. Instances of this association of the lime zeolites with a large supply of lime in the vicinity are common. When there is little or no lime, or only the results proceeding from the decomposing rock, the other zeolites are formed—the hydrous silicates of alumina and potash or soda, occasionally with some lime. But if a salt of baryta or strontia is present, the decomposition of the silicates of the alkalies takes place as by the lime, and the mineral harmotome or Brewsterite is produced.

In the above explanations we have scarcely appealed to one source of amygdaloidal minerals admitted in the outset—their proceeding from vapors rising with the erupted rock ; for it seems to be of but limited influence. Besides the arguments already brought forward, we state that the vapors which rise at the moment of eruption are insufficient. They inflate the rock, or blow up the cavities ; but the little vapor required to open the cavities most assuredly could not afford by condensation the mineral matter necessary to fill them,—to produce stalactites, stalagmite and successive layers of minerals. The vapors then, if the source, must have continued to rise for some time afterward. But is it possible that vapors should rise up through the solid rock ? Such does not happen about recent volcanoes ; for fissures are first opened and then the vapors escape. And could it happen with the water above pressing down into the rock with the force of an ocean even a mile deep ?

There may be instances of this mode of formation ; but that it should be the usual mode is irreconcilable with the many facts stated. The form and condition of quartz or chalcedony in geodes, as well as the vast amount of this mineral in some cases,—the rela-

* Carbonate of iron seems never to form from water at the surface, its solutions depositing a hydrated peroxyd of iron instead of the carbonate : it may therefore require a submerged condition of the rock, although not necessarily a raised temperature.

tive positions of the zeolites, and their occurrence as incrustations on rocks, or as fillings of cavities or seams, and never in disseminated crystals through the texture of the rock,—the green coating of the nodules, which is sometimes a carbonate of copper when there is native copper in the rock to undergo alteration,—the correspondence between the elements of the minerals and the composition of the including rock, and at the same time their contrast in being hydrous while the constituents of the latter are anhydrous,—and the known formation of zeolites in caverns,—these various facts appear to establish infiltration as the principal means by which amygdaloidal minerals have been produced.

ART. VII.—*Considerations respecting the Copper Mines of Lake Superior;* by D. RUGGLES, 1st Lieut. 5th Regt. U. S. Infantry.

RECENTLY I had the honor to communicate some particulars in relation to the copper mining region, as well as the discovery of a vein of black oxide of copper, tinged with the carbonates, near Copper Harbor. Now, I propose extending those views, accompanied by observations touching collateral points, and deem it proper to recapitulate some of the circumstances connected with this discovery, as a basis for more extended observation.* It has already been stated, that the troops, while engaged about the middle of November last, in making some slight excavations, connected with the establishment of this post, found some bowlders of black oxide of copper of great density, richness and beauty, inducing an examination of a circuit of some fifty or sixty feet in diameter, from which some tons of bowlders, of uniform composition, were taken. (See fig. 1.)

Description of Fig. 1.—A. Copper Harbor.—B. Lake Fanny Hooe.—C. Lake Martha Stevenson.—D. Lake Clara Geisse.—E. Fort Wilkins.—F. U. S. Mineral Agency.—G. Pittsburgh company's cabins.—H. Main channel.—I. Centre reef.—K. Lake Superior.—Q. Lake Anna Stannard.—L. Silicate of Copper.—*m.* Bowlders of black oxide.—*n.* Trap dykes protruding.—*n'*. Mother trap range.—Scale of diagram, nearly two inches to the mile.

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* The present communication appears in a great measure to supersede the previous one received Feb. 12, 1845. That paper, agreeably to the author's wishes, has been forwarded to another destination. The historical fact, cited by him anterior to 1821, may be found in Mr. Schoolcraft's memoir in Vol. III of this Journal, p. 202, with a figure of the large mass of native copper, now at Washington.—*Eds.*

Fig. 1.

The superficial stratum is, in general, conglomerate. Lake Fanny Hooe, is a pretty little lake, nearly three miles long, half a mile broad, and averages about sixty feet in depth; its waters are brackish, resembling brandy and water, and unpalatable. This lake is fed by diminutive rivulets, rising in small lakes in the immediate vicinity, and is seldom if ever subjected to inundation; a conclusion warranted by the traces of a beaver dam still visible at its outlet, affording satisfactory evidence of the tranquillity of its waters. Its surface is about fourteen feet above that of the harbor. (See section, fig. 2.)

Fig. 2.

Range S. 15° W. through M. Scale 3 inches to 1 mile.

D. Lake Superior.—*a*. Lake shore.—*b*. Silicate of copper.—*c*. Elevation, 20 feet.—E. Harbor shore.—A. Copper Harbor, 40 feet deep.—E′. Harbor shore.—F. Fort Wilkins, isthmus, elevation 32 feet.—*o*. Vein of black oxide of copper.—*n*. New red sandstone.—*m*. Bowlders of black oxide.—*g*. Lake shore.—B. Lake Fanny Hooe, 60 feet deep.—*g′*. Lake shore.—*n′*. Mother trap range, 200 feet elevation.

o above E′, 32 feet.—*o* above *n*, 8 feet.—*n* above *g*, 10 feet.—*n′* above *g′*, 200 feet.

The point *o* is distant about forty yards from *g*, and at *o* the vein of black oxide rises within two feet of the surface, through well-defined walls of conglomerate rock, near the crest of an elevation of eight feet above the crop of the new red sandstone. The latter rock dips some degrees towards the harbor, and rests upon, at its outcrop, most probably, a trap dyke, running parallel with the small lake. The metallic bowlders were found at *m*, in a stratum of drift, consisting of coarse gravel intermixed with a variety of pebbles and bowlders, presenting the characteristics of a well-worn shingle beach. During the progress of discovery, the first question was, whether these metallic bowlders were genuine drift, in their present distinct masses, or an accidental deposit from an iceberg,* subsequently broken into fragments; or, indeed, of local and isolated formation. Their number, density, and uniform composition, together with evident marks of attrition and abrasion in the characteristic stratum in which they were found, left no doubt in my mind that they were genuine drift; and accordingly, keeping in view their clustered position and density, that they were, at a remote period, driven from a vein of identical composition. This naturally led to the examination of a faint undulation, near the crest of the elevation close at hand; which proved to be a crevice in which the vein was subsequently found, and in which a space of some twenty feet, filled with detritus containing occasional bowlders of ore, confirmed my previous convictions, that it was from this crevice the whole mass of metallic bowlders had once been driven.

Another enquiry necessarily follows, viz. to what agency must the translation of these bowlders be attributed, and did the united agency of present causes produce these results? It has been already remarked, that the bowlders were found about ten feet above the present surface waters of the lake, and that the vein lies in the slight elevation some eight or ten feet above the bowlders. It is to be observed, that the vein ranges, under a small angle with a perpendicular, to the longitudinal axis of the lake and the direction of the subterranean dyke; consequently, some of the heaviest bowlders must have been transported fifty or sixty feet, and almost all nearly that distance, over the crop of the new red sandstone. These masses have a density approximating

* This, also, would be comprehended under the general scope of drift.—Eds.

closely to that of cast iron. The conclusion is therefore evident, that present causes* combined cannot, by any possibility, have produced such a result; and that it is attributable to the agencies of the great diluvial or drift period, or those of subsequent action, and which have long since reposed in equilibrium. If we survey the geological aspect of the surrounding district, the indications of causes sufficiently powerful meet us on every side. A species of well characterized trap-conglomerate extends westwardly along the southern coast to the head of Lake Superior, also several miles inland, embracing an area, probably, unparalleled in the history of this formation. This stratum is composed of pebbles and small bowlders of every variety and description, cemented by calcareo-siliceous matter firmly solidified, disclosing clearly defined traces of ancient igneous action. On the elevated range south of the small lake, where the mother trap appears, the conglomerate has been ruptured along its longitudinal axis, and pitched outwards, and even now displays the ragged faces of large masses once violently fractured. But in the vicinity of the lower trap dykes, the disruption of the conglomerate has in a great measure disappeared under the ancient abrasion of incumbent waters, while the rock was still comparatively soft—from the elements of which a partial re-arrangement resulted. Thus remarkable inequalities in the thickness of this stratum have arisen. The numerous trap dykes and traversing fissures, as well as the peculiar tinge of the new red sandstone, disclose unerring indications of a remote period of volcanic or igneous action. There is, also, in this vicinity, a remarkably well characterized *stratum* or *bed* of black oxide of manganese. It crops out in the precipitous bank of the creek leading from Lake Martha Stevenson to Lake Fanny Hooe, at *g*. (See fig. 1.) An extent of some sixty feet is developed, and is about two feet in thickness; it is compact, intermixed with and disseminated through a pearly, semi-crystalline calcareous spar. The stratum runs in a lateral direction, and the crop ranges at an angle of at least 45° with the horizon, parallel with the course of the creek and perpendicularly to the axis of the mother trap range, over which it doubtless lies. The undulating appearance of the crop, the high angle under which it is

* The author doubtless intends by "present causes," those that are now operating under existing circumstances, in that region; he doubtless admits that the causes, whatever they have been, are still existing, and elsewhere in action.—Eds.

presented, together with the lateral direction or bearing westward, and the associated semi-crystallized limerock, seem to prove incontestably that this once constituted a bed or horizontal stratum attributable to aqueous origin, subsequently solidified—perhaps purified—and elevated into its present position by volcanic or igneous action.

It is also worthy of remark, that an extensive vein of calcareous spar, of a well characterized crystalline structure, is situated at *u*, on the shore of Lake Superior, and is some eight feet in breadth; and east of this about two miles, a similar vein of four feet in width is found. Now, if we assume that these veins, as well as the great number of a similar character holding the same general bearing, namely, S. 15° W., are attributable to igneous action, under great pressure, analogous experiments prove that it is a rational deduction. (See Hitchcock's Geology, p. 244.) The conclusion would therefore seem irresistible, that the Copper Harbor vein of black oxide was formed either under the pressure of water, or submerged during a long period after formation, when the metallic bowlders in question were driven from their original position. In connection with this conclusion, I observe, that there is evidence of gradual elevation at remote periods, without corresponding subsequent depression. The south shore of Lake Fanny Hooe appears to have been, upon its narrow margin, at one period, a regular beach, judging from its inclination and the composition of the detritus, which would have made the narrow isthmus where the fort now stands a sunken reef, as well as the arms of the present harbor, while the small lake must have been at one period a safe and commodious harbor amid the dreary waste of waters surrounding. In the present instance, the elements have placed a record within our reach, by which we can determine approximately that this region has found uninterrupted repose during a long period past, and that the forces from which the present aspect and order of things resulted, are now held in equilibrium. We observe that a trap-dyke ranges and sinks in front of the landing at this post. (See fig. 1.) *n t*, is about 200 yards long, and a perpendicular from its centre strikes the shore at the distance of 100 yards. The east bank of Fort Wilkins creek has been swept away at least eighty yards inland from *t*, whilst the western bank of the same composition still remains entire—protected by the dyke in front from the violence of the open roadstead waves. The superficial portion of the isthmus, close at hand, is composed principally of the detritus of conglomerate, and as we descend, this rock is disclosed in its characteristic solidified form. The space thus presented near the landing sinks from the beach outward to twenty-five feet water, and lies before the eastern channel of the open roadstead—leaving the mind to comprehend, involuntarily, that it has been gradually cleared of an immense mass of conglomerate and its detritus by the abrading waves. Nearly opposite the western roadstead channel, at *t′*, a similar impression has been made upon the isthmus. The evidence of cause and effect is here strikingly exemplified by the result, and the conclusion is therefore rational, that a long period of repose has elapsed since disturbing forces have left records of their power. Nevertheless, I regard the Kewaiwenon peninsula as the result of progressive elevating periods, and accordingly that most if not all of the mineral veins throughout this region have been formed by volcanic or igneous action, under the pressure of incumbent waters. That the trap was first projected through the conglomerate, and that then the mineral veins were formed, there can be little doubt.

I have entered into these details because I regard this region as presenting many striking peculiarities, a knowledge of which will become of great importance as the mines are progressively developed, and which will be found to extend, by practical analogy, to the whole mining region of the northwest; and I know of no method by which to arrive at important and practical generalizations in the geology of mining, except by a just appreciation of elementary indications and principles. I am not aware that any more remarkable instance is found on record where metallic bowlders, of great richness, density and beauty, have been traced, in a manner so satisfactory, to the parent vein. The question is thus presented, hypothetically, whether the true veins, containing copper and its combinations, were formed by subterranean igneous agency, under the pressure of incumbent water, or subjected only to the pressure of the atmosphere; and the same views extend, by analogy, to the lead mines. The question is very important as regards the origin of mines, and especially since this rich vein appears to have been formed and preserved under the pressure of a great body of water,—while disseminated metallic copper, found in many veins, may possibly indicate that portions of the valuable combinations of this metal have been destroyed and dispersed by subterranean heat in consequence of the absence of pressure.

I will now endeavor to indicate, briefly, the vast region to which this question has direct application. The general dissemination of copper, and indications of its combinations, extending from near Grand Island along the southern shore of Lake Superior to its head, and several miles inland, as well as abundant indications on Isle Royale, near the N. W. coast, is now well established. The native copper bowlder, so long known to have lain in the Ontŏnāgon, has been very justly regarded as an anomaly in the mineral kingdom. There is also an inland trap range running some two hundred and thirty miles south of the Kewaiwenon bay, and extending inland past "Lac Vieu Desert" towards the sources of the Chippewa and Wisconsin rivers. Indications of copper and its combinations are said to have been found throughout the whole extent. The Indians describe a massive bowlder of native copper, surrounded by calcareous spar bowlders, a little to the west of "Lac Vieu Desert," so vast that actual examination alone would overcome incredulity. I have received authentic accounts of small fragments of native copper found in sand-rock by troops, in 1819, '20, while quarrying near the junction of the Mississippi and St. Peter's rivers, for building Fort Snelling, and where the hand of man could never have placed them. Recently ores of copper have been discovered, in the vicinity of Prairie du Chien, estimated to yield twenty per centum. Some eight or ten years since, a mine, bearing nearly N. and S., containing earthy oxides associated with the ferruginous sulphuret, yielding about fifteen per cent., was opened near Mineral Point, and since then other localities have been discovered in its vicinity.

A large portion of this region, especially that comprised within the Mississippi valley, which has come under my personal observation, presents clear and abundant traces of submergence during a remote period—this, indeed, independent of the incontestable evidence indicated every where by organic remains; of these waters, the Mississippi appears to have been the final outlet. A similar subsidence, though less clearly indicated, probably took place contemporaneously in the region of the great lakes, through the valley of the St. Lawrence.

Now it is to be observed, that galena is found geologically associated with copper, in strata flanking the trap ranges, and at distances from their axes, subjecting them but partially to the influence of the great disturbing cause. It is also to be observed that in the immense mining district embracing portions of Illinois, Wisconsin and Iowa, galena is generally found in the older secondary limerock, in fissures ranging north and south, east and west. The former is usually crystallized in cubes, and the latter frequently laminated. At Dubuque these fissures lead through extensive caverns, in which immense masses of galena are found. The geological position of this ore is precisely that which we might reasonably anticipate, as resulting from the projection of metallic lead, enveloped in a dense atmosphere of sulphur from the fountain of igneous action, through fissures in the rock strata, resulting from concurrent disturbing causes, under the pressure of an immense mass of water—otherwise the sulphur would have escaped by sublimation, and the lead sunk or entered partially into other combinations. This opinion is in a measure confirmed by the fact, that blende, sulphuret of zinc, is very generally associated with, and indeed usually overlying, galena in the mining region; which accords with reason, as indicated by their relative specific gravity—being 4 to 7.5—taken in connection with the sublimation of zinc unconfined after fusion. Thus, experience seems to prove that atmospheric pressure is entirely insufficient to produce condensation, and hold this metal in combination. Galena is also found in beds of alluvium, where it may have been projected in its nascent state, or subsided under the abrasion of the subsequently receding waters, which destroyed extensive portions of the metalliferous limestone stratum. Experience shows, moreover, that galena is very generally imbedded in, or associated with, a species of plastic mineral clay, with indications of oxidation. The combinations of copper at Mineral Point and Prairie du Chien, are probably accidental projections from the seat of igneous action, and consequently of rare occurrence in that district, where the limerock is supposed to average one thousand feet in thickness. This corresponds, I conceive, with observations made in the copper-mining region, connected with the disappearance of mineral veins in very thick, overlying conglomerate.

In most cases, boring should precede mining, as this simple and comparatively cheap operation will decide the question of the existence of ores in profitable quantity.

Fort Wilkins, February 26, 1845.

ART. VIII.—*Singular case of Parhelion, with a statement of the Theory of ordinary Halos;* by Prof. E. S. SNELL, of Amherst College.

ON the 23d of last March I witnessed an optical phenomenon in nature, which was to me entirely new. The sun had ascended eight or ten degrees from the horizon, and I was stepping from my door, which opens to the east, when I was surprised to notice a luminous curvilinear band, three or four feet wide, thickly studded with shining points of every prismatic hue, stretching over the dead grass of the wide street before me. Its form seemed to be that of a parabola or hyperbola; its nearest point, which was the vertex of the curve, was not more than twelve or fifteen feet distant, and its two branches extended several rods, one to the right and the other to the left of the sun,—the axis being the intersection of the ground plane with a vertical through the sun and the eye. Though the band could be thus distinctly traced, yet the illumination was not continuous, as in the rainbow, but pencils of intense light were seen to come from innumerable but separate points; and these exhibited, without much order of arrangement, the countless shades of the prismatic spectrum. As I moved, the luminous arch moved also in the same direction, so as to retain its relations to my eye and the sun, while the individual points changed from hue to hue and were extinguished, and others started into sight, to twinkle for a moment in their turn, and then disappear.

My first thought was, that it was the lower limb of a rainbow, such as I have often traced in dew-drops, as they rest on vegetable leaves and are strung upon spider lines that are stretched along the grass. Its form appeared the same as the rainbow must assume when seen in such circumstances. But it was in the *wrong direction;* I stood *facing* the sun, and the colors plainly came from points not more than thirty degrees from it. I perceived in a moment, however, that there were no dew-drops, but that the spires of dead grass were feathered over with frost crystals of unusual size. The true nature of the phenomenon instantly flashed upon my mind; and I was delighted to witness a most interesting confirmation of the truth of the generally received theory respecting the large solar and lunar halos. In the first place, though the colors were scattered promiscuously, yet there was evidently a prevalence of the red on the most distant, that is, the concave edge of the band. And in the next place, I ascertained, by a rude measurement, that the distance of the curve from the sun was about twenty two degrees. These two particulars characterize that species of halo, most frequently seen encircling the sun and moon, respectively called the *parhelion* and the *paraselene.**

The only hypothesis offered for the explanation of the halo of 44 or 45 degrees in diameter, which is at all satisfactory, is that of M. Mariotte and Dr. Young, who considered it the effect of the transmission of light through snow crystals, whose refracting angle is 60°. This is known to be one of the most frequent angles in such crystals. The index of refraction for ice is about 1.31.

Now suppose a pencil of light to traverse a prism of ice, whose refracting angle is 60°, in such direction as to cut perpendicularly the bisecting line of the refracting angle ; this pencil will be found, by a simple calculation, to deviate 21° 50′ from its original direction. If the prism be revolved either way from the position just named, the angle of deviation will increase ; yet so slowly at first, that a change of 10° in the prism will not occasion a disturbance of more than one fourth of a degree in the emergent ray. But if the prism be revolved through large angles, the deviation increases more rapidly ; and the greatest deviation occurs, when the prism is revolved in one direction, till the angle of incidence equals 90°, or in the opposite, till the angle of emergence is 90°. In either case, the deviation I find to be 43° 27′ ; this is the maximum.

Let there be a stratum of these crystals floating in the air, of such depth as to produce only haziness, through which, of course, the sun can be plainly seen. The refracting edges must be supposed to lie in all possible positions. We are at present concerned only with those whose edges are perpendicular both to the line of vision and the solar ray, and whose refracting angles are turned away from the axis, or line joining the eye and the sun. And of all such, it is plain that no crystal, lying nearer the sun's

* These terms are often used to designate those bright images of the sun or moon, sometimes seen at the intersection or contact of two halos, also called *mock-suns* and *mock-moons*. But I find good authority for applying the words to the halos themselves.

direction than 21° 50′, can transmit a ray to the eye of the observer; otherwise the deviation would be less than 21° 50′, which, according to the above calculation, is the minimum. But those crystals, which are about 22 or 23 degrees from the sun, may, as already stated, be revolved on their own axes, so as to change the angle of incidence 10 or 15 degrees, and yet send their transmitted ray to the eye. Some of these positions are represented at B, in the figure.

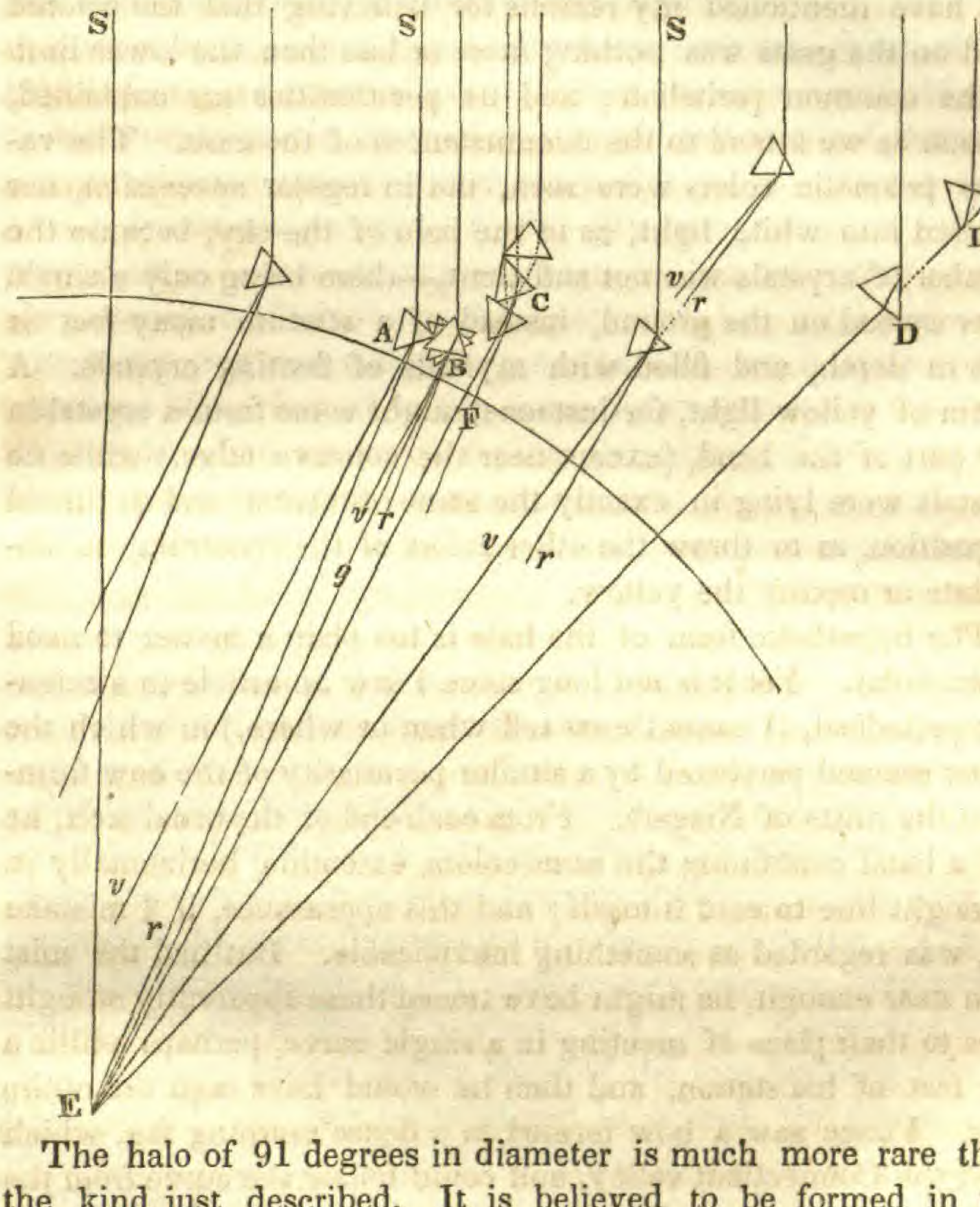
That I might render my own ideas of the case as definite as possible, I constructed the following table, for every five degrees of incidence.

Angle of incidence.	Angle of emergence.	Angle of deviation.
13° 27′	90°	43° 27′—maximum.
15°	79° 19′	34° 19′
20°	66° 40′	26° 40′
25°	59° 37′	24° 37′
30°	53°	23°
35°	47° 9′	22° 9′
40°	41° 51′	21° 51′
40° 55′	40° 55′	21° 50′—minimum.
45°	36° 59′	21° 59′
50°	32° 30′	22° 30′
55°	28° 22′	23° 22′
60°	24° 43′	24° 43′
65°	21° 28′	26° 28′
70°	18° 42′	28° 42′
75°	16° 28′	31° 28′
80°	14° 48′	34° 48′
85°	13° 49′	38° 49′
90°	13° 27′	43° 27′—maximum.

This table shows that no crystal can transmit light, unless so situated that the angles of incidence are between 13° 27′ and 90°, on that side of the perpendicular most remote from the refracting angle. This range equals 76° 33′. It shows, also, that if the angles of incidence are between about 29° and 55°, (a range of 26°, or one third of the whole,) the emergent ray will vary but about *one degree and a half* from the minimum deviation. Hence, of all the light which can come from the sun by transmission through crystals of 60°, one third is refracted by those which lie within the narrow limits between 21° 50′ and 23° 22′. Therefore, although the entire width of the halo is 21° 37′, (=43° 27′−21° 50′,) only one or two degrees of the inner border will be noticeable. But the inner edge of what seems to be the entire halo will be tolerably well defined, and the outer edge will shade off gradually to the light of the sky. Every careful observer must have noticed, that the area lying within the halo is darker than that without. The reason is made obvious by what has just been stated; the space which is regarded as outside, is in fact a part of the halo itself.

Every crystal decomposes as well as refracts the light, and no one can send more than a single color to the eye. But other crystals, closely contiguous, by slight differences of position, may transmit other colors; and the effect will, in general, be that of white undecomposed light. On the inner edge, however, the red may almost always be seen, uncombined with any other color, because no other can deviate so little from the original direction,—red being the least refrangible, and the crystals being, by supposition, at the minimum limit. Outside of the red, the other colors are sometimes seen in the prismatic order, growing more and more faint, from the mixture already spoken of. For instance, suppose a crystal B, at such a distance from the axis, E S, that when lying in the position for minimum deviation, it throws the green ray to the eye; then other crystals in the same visual direction, on which the light falls at angles of incidence a little larger and a little smaller, will also refract the same color to the eye, on account of the slight changes in deviation which occur there; but there are others, still farther revolved, which will bring the less refrangible colors, yellow, orange and red. And thus the green, though predominant, is rendered impure. The violet at C is partially neutralized by *all* the other colors, and can rarely be seen. Beyond the colored ring, whose width is represented by A B F, the light, though just as much decomposed, is reduced to whiteness again by the union of all the colors from crystals in different positions. In the rainbow, the several colors are equally pure and distinct. The reason of this difference is obvious. If the *distance* of a rain-drop from the axis of the bow be given, the color thrown to a certain point is given also, because a revolution of the drop in its place does not change the relations of its surface to the sun, or to the observer's eye. Not so with a crystal; both *dis-*

tance and *position* must be given, or the color transmitted to a particular point is indeterminate. In the accompanying figure, the eye is supposed to be at E; the sun in the direction of E S, A S, &c. A represents a crystal at the inner edge. D and D′ show the different positions at the outer edge. The other parts of the figure will be understood from the preceding description.



The halo of 91 degrees in diameter is much more rare than the kind just described. It is believed to be formed in the same manner by crystals of 90°; and this angle occurs in the crystallization of water with much less frequency than the angle of 60°.

Halos occur in summer as well as in winter; for vapor often floats higher than the limit of perpetual congelation.

The halo of 44° in diameter is a phenomenon of very frequent occurrence. I have reason to believe that it might be seen, more or less perfectly formed, on an average one day in a week the year through. In the year 1839, in which I watched for this phenomenon with more than usual diligence, I recorded *forty nine* halos; of which *forty four* were formed about the sun, and *five* about the moon. And I cannot question that several, during the year, entirely escaped my notice.

I have mentioned my reasons for believing that the colored band on the grass was nothing more or less than the lower limb of the common parhelion; and its peculiarities are explained, as soon as we attend to the circumstances of the case. The various prismatic colors were seen, not in regular succession, nor blended into white light, as in the halo of the sky, because the number of crystals was not sufficient,—there being only a single layer spread on the ground, instead of a stratum many feet or rods in depth, and filled with myriads of floating crystals. A gleam of yellow light, for instance, might come from a crystal in any part of the band, (except near the concave edge,) while no crystals were lying in exactly the same direction, and so turned in position, as to throw the other colors of the spectrum, to obliterate or modify the yellow.

The hyperbolic form of the halo is too plain a matter to need explanation. Yet it is not long since I saw an article in a scientific periodical, (I cannot now tell when or where,) in which the writer seemed perplexed by a similar peculiarity of the bow formed in the mists of Niagara. From each end of the usual arch, he saw a band containing the same colors, extending horizontally in a straight line toward himself; and this appearance, if I mistake not, was regarded as something inexplicable. But had the mist been near enough, he might have traced these apparently straight lines to their place of meeting in a single curve, perhaps within a few feet of his station, and then he would have seen the entire bow. I once saw a bow formed in a dense morning fog, which filled the Connecticut valley, and could follow the curve from the fog into the dew on the grass; and the nearest point was not more than four feet from the place where I stood; so that, with a walking-staff, I could have extinguished the most beautiful part of the phenomenon. The higher and remoter part of the bow was circular, the lower and nearer part was hyperbolical. It is obvious, that in every such phenomenon, the light forms the surface of a cone, whose vertex is at the eye; and if the bow is seen projected on a surface perpendicular to the axis, it appears circular; if on an oblique surface, it will assume the form of an ellipse, parabola, or hyperbola, according to the degree of obliquity. The form in the particular case I have described was that of a hyperbola; because the axis *ascended* from the eye toward the sun, while the surface on which the halo was projected was *horizontal*, or slighly *descending*.

It surprises me much that I have never seen any thing of the kind before; and more still, that I have never seen it referred to, as an argument in favor of the hypothesis which I have attempted to state somewhat in detail in this paper. To my mind it is a demonstration of its truth. My engagements at college were such as to prevent my watching for the recurrence of the phenomenon while cold weather continued, but Dr. Hitchcock, whose attention was called to it on the 23d, saw it again a few mornings after, formed in the same circumstances; and I think it might be often witnessed during the season of frost, as one of the glories of a sunny morning.

Amherst, Mass., April, 1845.

Art. IX.—*Notice of a New Species of Batrachian Footmarks;* by James Deane, M. D.

While recently engaged in searching the sandstone beds of Connecticut River, for its peculiar fossils, my attention has been frequently arrested by a pair of singular footsteps, which were accompanied by other impressions of obscure character. The pedal impressions consist of five massive toes radiating from a tarsal centre, like the spokes of a wheel, and a line intersecting them from centre to centre, leaves three of the toes pointing forward and outward, and two outward and backward, the whole completing a semicircle. (See the diagram, A. A.)

Regarding these anomalous imprints to be due to quadrupeds specifically different from any thing hitherto observed, I sought diligently for the corresponding set of members, but without success. From the position of the feet, it was apparent that the progressive movement of the animal was by *leaping*, and this opinion was corroborated by the many instances that came under my observation, the position of the feet being in all cases identical. The lobate forms of the joints, with the claws, were accurately impressed, and hence the inference, that if the other set of feet touched the ground, their forms would necessarily have been retained. But on the contrary, there is situated, invariably, behind each footprint, a deep elliptiform impression, pointing forward and somewhat outward, the pair being more widely separated than the footprints. (See the diagram, B. B.)

From a patient investigation of these curious forms, aided at length by an exquisite specimen, the inevitable conclusion is, that the compound impressions were produced by the animal when advancing by leaps, and that from its peculiar organization, one set of feet did not touch the earth.* It is difficult to explain

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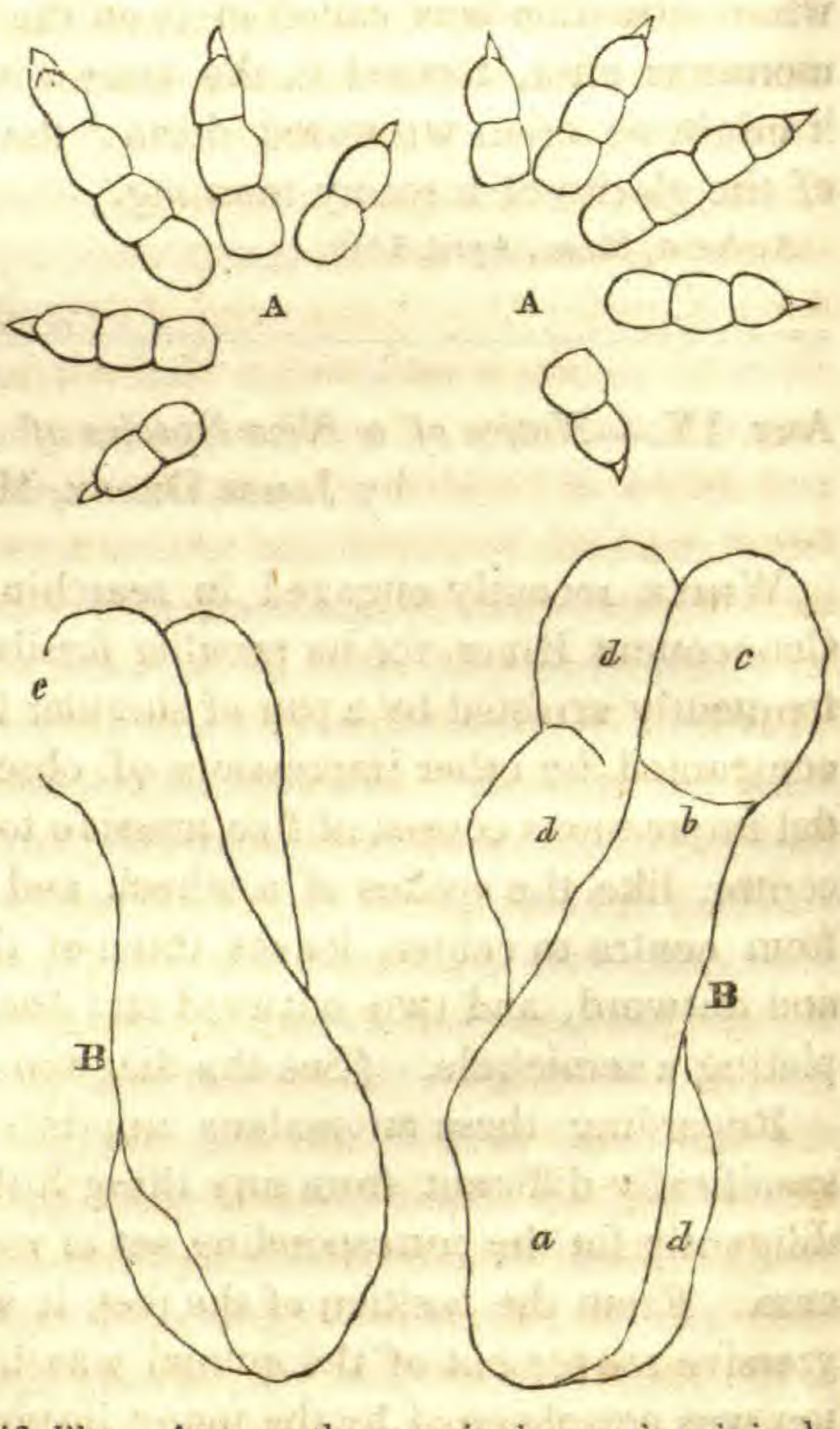
* To render these views more intelligible, the accompanying diagram is given, taken from a beautiful specimen in the possession of T. LEONARD, Esq., reduced one half in linear measure.



A, A. The footprints. Each foot is comprised of five toes, the central one having four articulations, while each lateral one from it, diminishes in number by one, in their order. The impress is exquisitely fine. The spread of each foot, or rather its diameter, measures two and one half inches. B, B. The posterior oblong impressions, five inches in length by one and one half in breadth. The outline is not only irregular, but the impression varies much in depth. It is a deep concavity at *a*, and becomes superficial at *b*. It is deep and concave at *c*. At *d*, *d*, *d*, it is superficial, but the outline is clear. The appearance of this impression suggests the probability that it was produced by the flexed limbs while in a sitting posture, *a*, *b*, *c*, being the first or lower joint, and *d*, *d*, *d*, the succeeding one, folded upon and overlapping it. The impression of the integuments, is absolutely life-like. At *e*, on the opposite impression, it is obliterated by a splendid ornithichnite. The impressions in question are associated with several species of bird tracks and with rain-drops in wonderful preservation.

this phenomenon, although the presumption is, that the animal was some Batrachian reptile. It is not improbable however, but the entire aggregate of impressions were made by the posterior feet and limbs, the fore feet not reaching the ground, after the fashion of the kangaroo. This method of locomotion would certainly be adapted to the turbulent era in which the animal lived. But I will not indulge in speculations, contenting myself with reciting facts, and leaving it to the learned reader to draw the inference.

I have also drawn from this prolific rock, other marvellous signs of once living creatures, to the interpretation of which, I know of no analogies to apply. The study of the sandstone fossils, grows intensely absorbing. It incessantly reveals to our admiring eyes, new modifications of ancient life, which, although they seem incomprehensible, are nevertheless authentic evidences of harmonious creation.

Greenfield, Mass., May 21, 1845.

Art. X.—*On the Copper and Silver of Kewenaw Point, Lake Superior;* by C. T. Jackson, of Boston.

A brief description of the geology and mineral resources of Lake Superior, may not prove unacceptable, at a time when public attention is called to that region, and mining enterprises are about to be entered into by many individuals and companies, some of whom have already gained valuable information concerning the most important mines, while others may be acting under erroneous impressions and hopes which may not be fully realized.

The earliest accounts of the metals found on the coast of this lake, are those of Alexander Henry, who travelled around its shores in the years 1760 and 1776, and published his researches in 1809 in an octavo volume—printed in New York; and of Capt. Jonathan Carver, who visited the lake in 1766, and published his travels in a similar volume in Philadelphia in 1796. Both Henry and Carver describe numerous loose pieces of metallic copper, found on the lake shore, and express a favorable opinion of the probable value of the country for mining purposes. Mr. Norberg, "a Russian gentleman acquainted with metals," who accompanied Mr. Henry, discovered, among the pebbles and loose stones on Point Aux Iroquois, a blue, semi-transparent stone, weighing eight pounds, which he carried to England and deposited in the British Museum. This stone, he says, yielded sixty per cent. of silver. *Quere.* Was not this a mass of chloride of silver? If it is still in the British Museum, I hope some one will give an account of it. It is somewhat remarkable that neither of these travellers discovered copper or silver, or their ores, in the rocks in place.

Since those ancient explorations, many individuals have travelled on the lake shores, and have described generally the loose masses of metallic copper seen in the soil or in the possession of the Indians. Henry R. Schoolcraft has given us a very particular description of those which were seen by him during his excursions with General Lewis Cass. He visited the great copper bowlder on the Ontanagon River, and has published a very accurate account of it in his travels, and in this Journal, Vol. III, with a plate.

So far as I have been able to learn, no full description of the rocks and ores found in place has been published, excepting those of Dr. Douglass Houghton, who has given a general account of the geological structure of the country, and of the metalliferous contents of the rocks, in his interesting annual reports on the geological survey of Michigan. A full and detailed description of the minerals and mines of that country, will be published in his final report, which will appear on the completion of his extensive and arduous surveys.

My object in this communication, is to give an account, for the information of miners and mineralogists, of the region which I have specially explored; and in order to a more full understanding of the subject, I shall have to explain the geological structure of the country in which the mines are situated.

I trust that some of my observations will prove interesting to the scientific community, as well as to those interested in mining.

In July, 1844, I was employed by the trustees of the Lake Superior Copper Mining Company, to visit and examine certain tracts of land on Kewenaw Point, of which they had procured leases from the United States government. In the performance of this duty, I was assisted by Messrs. C. C. Douglass, Joseph S. Kendall, and Frederick W. Davis, and was accompanied by Hon. David Henshaw, one of the board of trustees.

After a pleasant journey and voyage from Boston to Mackinaw, we took a boat for the Sault St. Marie, and made a trip of about ninety miles from Mackinaw to the Sault, encamping two nights on the islands on our route, and reaching Lake Superior on the evening of the third day. Most of the islands which we passed were composed of compact white limestone, containing a few fossils, and apparently of the same age as the Niagara limestone of New York, and like it containing occasionally a little gypsum. On reaching the Sault, the character of the rocks is altogether changed, and red and grey sandstone, which, according to Dr. Houghton, is of the old red series and destitute of fossils, is observed, and forms the falls or rapids by discharging the waters of Lake Superior over the outcropping edges of their strata. The sandstone dips towards the lake, and the waters, passing up their gently inclined surface, fall in foaming rapids from the upper edges of the strata; while along the whole upper side of this slope, myriads of large rounded blocks of primary and trappean rocks have been deposited by the sheets of ice, which must have transported them from a great distance—no such rocks being found in place near the outlet of the lake. These bowlders were probably brought by the ice, or streams coming from the mountains, to the lake shore, and from thence ice-rafts have transported them to their present resting places. They abound not only in the rapids, but also on the more elevated land around the falls, and indicate the ancient level of the waters of the lake to have been much higher than it has been during the historical epoch. The geologist will observe among these rounded blocks of stone, representatives of all the different rocks of the lake coast and of the country traversed by its tributary streams. Those which are most remarkable are syenite—often mixed with epidote, a mineral not unfrequently mistaken for copper ore—red porphyry, quartz rock, greenstone trap, conglomerate and red sandstone.

The rock in place beneath this covering of bowlders, as before observed, consists of strata of mixed red and gray sandstone, which is covered with only a few feet of sandy soil, and is fully exposed along the line of a little canal made for a now abandoned saw mill. This canal extends from the lake to below the falls, and is nearly a mile in length. The fall from the level of the lake to the river St. Mary below the falls, is from eighteen to twenty feet, according to the measurements which I made at the termination of this canal. The feasibility of constructing a ship canal from Lake Superior to the St. Mary's river is perfectly obvious, only three locks of six feet each being required for the purpose. The only difficult part of the work will be in preparing a good entrance into the canal from the lake, where a breakwater will have to be made to protect the boats and the mouth of the canal. This work the United States government contemplates, and it is to be hoped will soon execute. There can be no better ground for a canal, for it will be cut wholly through soft sandstone, easily wrought, but solid enough for substantial embankments, while the numerous erratic rocks near by, will furnish all the stone required for building substantial locks.

The sandstone on the lake shore at the head of this canal, dips to the S. W. 48° and runs N. W. and S. E. Dr. Houghton has observed that the strata of this rock, wherever it comes on the lake coast, dip towards the lake, and so far as my observations have extended, I was able to confirm this remark. If it should prove to be the case around the entire lake, which has not yet been fully explored, it would lead to some interesting geological conclusions respecting the formation of this great basin; for although there are many places where the elevation of trappean rocks has thrown up the sandstone strata at a bold angle, yet we should not be able to account for the elevation of so extensive a brim by local elevating forces; and since they act in directions deviating but little from a right line, or in gentle curves to the northwest, they would be inadequate to account for the phenomena, and we should have to regard the lake basin as a valley of depression.

At Eagle Harbor the sandstones have evidently been disturbed by the intrusion of trap rocks, and dip N. N. W. 25°, but still towards the lake shore. The same dip was observed two or three miles inland at Cat Harbor, and in every place where the sandstone was observed on the north side of Kewenaw Point. This would be accounted for by the direction of the great trappean ranges, which run in a general N. E. and S. W. course, in the peninsula, with a gentle curve to the northwest. The opposite or southeastern side of this point has not yet been examined, so far as I know, by any geologist, and it will be quite interesting to know the dip of the strata on that side of the trap rocks. If the dip should be to the northwest, then the trap dykes will be found to overlay the strata, after passing between them, just as they do at Nova Scotia, and on the Connecticut River, and at New Haven.

Having given some account of the sandstone strata, I would observe that the conglomerate rocks belong to the same system, and are evidently formed from the coarser pebbles and gravel, derived from primary and intrusive porphyritic and trappean rocks. The pebbles are all rounded and smooth, indicating the long continued action of water, and abrasion of the fragments of rock by attrition, in a manner similar to that we now observe on the sea coast, where the surges of the ocean are continually at work, grinding the loose stones against each other.

No remains of animals or of plants, unless indeed some obscure traces of Fucoides, have yet been found in the Lake Superior sandstones or conglomerates, and I understand that Dr. Houghton thinks he has satisfactorily traced this deposit below the coal bearing strata. If this should be fully established, the formation would be ranked as belonging to the old red sandstone series, although it so strongly resembles the sandstones of Nova Scotia and of the Connecticut River, that I have been disposed to regard it as higher in the series, and suspect it to belong either to the Permian or new red sandstone series; perhaps we have not yet sufficient data to fix the relative ages of any of our sandstone rocks, and it might be a useful work for some geologist to devote some years to their special study. The absence of characteristic fossils, prevents the ready determination of their age, and it will be required to trace the strata continuously until their relation to other rocks is known.

The conglomerate on Kewenaw Point is composed, as before observed, of pebbles of the older rocks cemented together by the more finely comminuted materials or clays, originating from their decomposition and disintegration. That the rock since its deposition has been acted upon by heat, is evident, not only from the induration of the cement and adherence of the pebbles, but also from the latter being cracked through the midst and separated from each other. Deep chasms are thus not unfrequently produced by the contraction of the sundered rock, and veins of calcareous spar often occupy the spaces. The calc spar often contains filaments of native copper, with a little of the carbonate, the latter being produced only when the vein is exposed to the atmosphere. When these veins occur near the trap dykes, analcime and Prehnite also abound, and were formed, without doubt, through the igneous agency of the trap on the contents of the vein and the ingredients of the wall rock. The spar veins are sometimes six feet wide, but their ordinary width is from a few inches to three feet. They generally traverse the strata at right angles to the line of strike, and resemble veins of igneous injection. The calc spar is highly crystalline in its structure, and the veins are too wide to have been formed by infiltration. If they were formed by the washing in of limestone, we would ask where the carbonate of lime came from, no limestone being found in this region. If the carbonate of lime was deposited as a tufa from mineral springs, then it has been since fused into calcareous spar by heat under pressure. If injected, then the walls of the veins should be silicate of lime, and should bear strong marks of fusion, which does not obviously appear. I am, therefore, still in doubt as to the origin of these veins.

Among the accidental ingredients in the conglomerate, the most remarkable is the green hydrous silicate of copper, which has long been known to the *voyageurs* on the lake as the green rock. This occurs at Hayes' Point, at Copper Harbor, and has recently been wrought by miners, who have extracted a considerable quantity of it.* The brown and black siliceous oxides also occur there, and are evidently the results of igneous action on the chrysocolla.† Black oxide of copper has lately been discovered in the conglomerate at Copper Harbor, at the military post called Fort Wilkins. The ore is a vein in the conglomerate, and is fourteen inches wide, and has been traced to the distance of fifty feet in length by the miners under the direction of Lieut. Ruggles.‡ Dr. Houghton has, I believe, found other veins of this ore in a similar rock, but has not yet given an account of the localities.

* The chrysocolla when free from rock yields from 25 to 30 per cent. of copper, but the average of the ore extracted from the mine, when picked as well as it can be for the furnace, gives but 9 or 10 per cent.

† This brown siliceous oxide contains,—

Copper,	51·08	per cent.
Silica,	20·00	"
Oxide of iron,	0·80	"
Oxygen and Water,	28·12	"
	100·00	

‡ This black oxide of copper yields from 68 to 70 per cent. of copper, and is a very valuable ore.

The most interesting rock on Kewenaw Point is the greenstone trap, which is there observed in immense dykes or ranges of hills, running in an E. N. E. and W. S. W. direction, or nearly parallel with the northwestern shore of the peninsula, with a slight curvature or convexity to the northwest. These trap dykes are equalled in extent only by those of Nova Scotia and the eastern part of Maine. They pursue the same course as those in Nova Scotia and are probably of the same age, and agree with them in most of their characters and in many of the included minerals, as also in their geological position. The trap rocks of Lake Superior pass through the red sandstone and conglomerate rocks, and are interfused with them, producing at and near their junction a very porous amygdaloid, which is always found at the lower side of the dyke where it is next to the sandstone, as is the case also in Nova Scotia.

On Kewenaw Point there are found in this rock very handsome agates, which at a place called Agate Harbor, form the pebbly beach. Stilbite, Laumonite, analcime, datholite, Prehnite and calcareous spar, are among the minerals frequently found in the geodes in the amygdaloid.

Prehnite and datholite also form veins in the trap, which are sometimes three or four feet in width, and of considerable extent. These veins also include native copper, and not unfrequently the individual crystals contain within them delicate leaves of the bright metal, not thicker than gold foil, while the whole mass of the vein is strung together by filaments of pure copper. The principal vein of datholite is situated in the rocks on the westerly point of Eagle Harbor, where it has been opened by the miners in search for copper. The finest specimens of Prehnite are obtained at the company's vein No. 5, three miles south of Cat Harbor. Analcime crystals are found in most of these veins, associated with calcareous spar.

Stilbite and Laumonite occur in the small geodes in the amygdaloid, and although generally disseminated are rarely obtained in handsome specimens. Heulandite, which is so abundant in Nova Scotia, was not observed in this region. Calcareous spar occurs in the form of the dog-tooth variety, and has a great number of planes on the angles and edges of the scalene dodecahedron, the crystals being the most complicated of any I have seen of the same species. Associated with this mineral, crystals of analcime as large as pistol and musket balls occur in trapezohedral forms. Some of them are very perfectly crystallized. The best specimen I have, was given me by Mr. Jacobs, one of the explorers of mines on Kewenaw Point.

Native copper is disseminated in the trap rocks and in most of the veins of other minerals found near it, but it is far more abundant in the amygdaloid, and not unfrequently fills the cavities in that rock. Isolated masses of many pounds weight are occasionally found, when the rock has undergone decay; and all the loose bowlders of metallic copper which are found at the mouths of the rivers and on the lake shore on Kewenaw Point, were derived from the amygdaloidal trap. The great copper rock found on the Ontanagon river, is an erratic bowlder, which was transported to that spot during the drift epoch, and originally was included in serpentine, a rock very different from any found in the Ontanagon district. Since the only known deposit of copper in serpentine is on Isle Royale,* and that island is nearly north from Ontanagon river, or in a direction from which the drift current came, it is supposed that it originated on that island and was transported in ancient times to the southward by an ice raft, which deposited it as a drift bowlder on the spot where it was found. I have not visited that locality, but form this opinion from the best information I could obtain. This great copper rock is now deposited at Washington, D. C. and is in possession of the Government. This enormous mass of metal, weighing between two and three thousand pounds, is well calculated to inspire too strong expectations of obtaining valuable mines on the coast of Lake Superior, and those who have such hopes should be warned that masses of metallic copper of that magnitude are great rarities, if indeed there is another like it in the whole country. Native copper is rarely a favorable sign in mines, and it is looked upon favorably only when it is so abundant as to constitute a considerable part of a large vein, or when it is pretty uniformly mixed with the rock. There are a few such localities on Kewenaw Point, and those I have examined with great attention. There are nine veins of native copper already discovered on the locations leased to the Lake Superior Copper Mining Company. Of that number only two

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* Dr. Locke is of opinion that the mineral supposed to be serpentine is epidote. I have not examined it.

or three have been selected, by my advice, as undoubtedly valuable, and of sufficient magnitude and richness for profitable mining. The others are problematical, and may perhaps ultimately be explored, by sinking shafts into them to some depth, when the value of the ore may be estimated.

The most valuable locality is on the west side of Eagle River,* eight miles from Eagle Harbor, and a mile and a half from the lake shore, on rocky land, elevated above the lakes about 200 feet. Fragments of the rock and lumps of native copper found at the mouth of the river, first attracted the attention of explorers to examine the bed and banks of the stream, when metallic copper mixed with silver was discovered in place. This locality was then examined by me, and by the aid of the company of miners the value of the mine was sufficiently proved to warrant the outlay required in exploring it thoroughly. An exploration shaft was then directed to be made, and the result has proved very satisfactory to the company.

The ore, if it may be so called, consists of an intimate mixture of copper and silver, and an alloy of those metals in an amygdaloidal trap rock, the cavities in it being filled with metallic globules, and fine particles being thickly mixed with the rock, so as to constitute from 10 to 30 per cent. of its weight.

The crevices and veins in the rock are also filled with thin sheets of an alloy of copper and silver, and occasional lumps of the metals are found of considerable magnitude.

The most singular and interesting chemical and geological phenomenon observed at this place, is the occurrence of pieces of copper and silver, united together side by side by fusion, without any alloying of the silver, although the copper contains $\frac{3}{10}$ per cent. of silver, united with it chemically. The silver, however, is always absolutely pure. There are also specimens in which the copper alloy is absolutely porphyritic, with patches of fine silver. I have a piece, about the size of a dime, in which one half of it is pure silver, and the other an alloy of copper with $\frac{3}{10}$ per cent. of silver, containing patches of pure silver mixed with it but not alloyed. The two metals are completely soldered

* Dr. Houghton says that this is not the stream known to *voyageurs* as Eagle River. I have therefore proposed to name it *Silver River*, a name evidently quite appropriate.

together at their points of contact. Other specimens exhibit square and triangular pieces of silver in the midst of the copper, or contain veins of it traversing the latter and firmly united at the edges. Crystals of silver, in the form of a regular octahedron, also occur, but are not common. Fine particles and strings of silver are more frequently observed. Glistening scales or fine crystals of antimonial silver ore are found in a part of the lode where the rock is most decomposed. Veins of quartz and of calcareous spar traverse some parts of the metalliferous rock, and the copper is most highly crystallized in the quartz; while the silver is more apt to be found in the calcareous spar or in the amygdaloid containing it.

The first exploration which I made at this place, was at the base of the cliff about three feet above the level of the river, and the rock was blasted away until the influx of water prevented further operations. The cliff is fifteen feet high, and presents a mural precipice, in which the metallic copper and silver could be readily discovered; and it was seen that the rock became richer as we descended, even though our researches were only to the extent of twenty feet from the top of the cliff to the place where we blasted for the last time. I felt confident, therefore, that the quantity of metals would increase in the rock to some depth; and in order to have this point settled, the miners were directed to sink a shaft, beginning on the top of the ledge and going down at least forty feet beneath the bed of the river. The shaft was then sunk, under the able direction of Mr. Charles H. Gratiot, the skillful superintendent of the mines, and its present depth from the surface is seventy four feet. By this exploration shaft, the value of the mine has been proved, and the proportions of metal were found to augment considerably as the work proceeded. Several hundred tons of rich ore have been raised, and among the fine specimens obtained, is a mass of copper with an ounce of pure silver attached to it. The ore raised is probably somewhat richer than that extracted by me, and will richly repay the cost of exploration.

Another exploration shaft has been sunk a few hundred feet farther from the river, and the ore has been found equally rich. These two shafts are now to be connected by a drift or level made along the course of the vein; one of the shafts will be used for ventilation and the other for the machinery used in hoisting the ore and pumping the water from the mine.

The vein has no regular walls, but on the upper side of the lode there is a line of division between it and the trap, where no metal is found. On the lower side, the copper extends to the distance of ninety feet, but the limits in which I calculate the ore to be rich enough to work, give but eleven feet as the width. Its extent in length is yet unknown, but it has been seen interruptedly for the distance of about half a mile—there being only a few places where it was uncovered.

Farther up Eagle River, at the distance of half a mile, a regular vein of copper was discovered in a rock composed of crystallized feldspar and chlorite—the vein stone consisting of a mixture of green earth, quartz and calcareous spar. It is from two to three feet wide, is fully exposed on the river's side for the distance of one hundred and ninety eight feet, and was seen interruptedly for a quarter of a mile. It runs N. by W., S. by E., and dips to the E. 83°. This vein contains lumps of pure metallic copper, some of which weigh from a few ounces to half a pound, and others are of an irregular form and as large as a man's finger. Smaller pieces are thickly interspersed in the vein stone. On analysis this metal was found to be perfectly pure copper, without any trace of silver—a curious circumstance, considering its proximity to the silver vein above described. It will be wrought for copper in conjunction with the other mine.

Analysis and Assay of the Eagle River Copper and Silver Ore.—In order to discover the real working value of an ore of this kind, it became necessary to make a selection of a fair average lot of the ore, of a quality such as could be depended upon as a regular product of mining operations. I therefore blasted off specimens from the whole width of the vein, and rejecting the sheets and loose lumps of metal found in the crevices, took fifty pounds of the rock, containing a pretty uniform and fair mixture of the metals, for analysis. This was crushed at Henshaw, Ward & Co.'s mills, and sifted in coarse and fine sieves to separate the flattened plates of metal, which weighed 11 lbs. 4 ounces, and consisted of plates of copper and silver mixed with a little rock. On being carefully washed, the weight of metal was reduced to 8 lbs. 13 ounces. This dissolved in pure nitric acid, and parted by chlorohydric (muriatic) acid and reduced, yielded 662·8 grs. of metallic silver—equal to $25\frac{2}{10}$ lbs. per ton. The copper amounted to 5 lbs. $8\frac{1}{2}$ ounces, or 1257 lbs. of copper per ton of coarse metal, as it comes from the washing table.

The fine sifted ore being washed, yielded 8 lbs. 12 ounces more of metal, mixed with heavy ferruginous particles of rock. This being dissolved gave 1 lb. 1 ounce of copper and silver, which when separated yielded 101 grs. of silver, and 1 lb. ¾ oz. of copper. The silver then in the fine washings is equal to $3\frac{4}{10}$ lbs. to the ton, and the copper from the same is equal to 250 lbs. Then 50 lbs. of the rock yield—

Coarse plates of metal, . . .	8 lbs. 13 oz.
Fine washed ore, ...	8 lbs. 12 oz.
Amount of washed metal in 50 lbs. rock,	17 lbs. 9 oz.

or 35 lbs. 2 oz. per 100 lbs. of rock, or 700 lbs. per ton.

The value of the coarse sifted metal after washing is per ton as follows—

For silver, 25 lbs. in a ton at $20 per lb.	$500 00
For copper, 1257 lbs. per ton at 16 cts. per lb.	201 12
Value of the coarse metal, . . .	$701 12

A ton of the fine sifted ore, washed and reduced as above described, yields—

Silver, $3\frac{4}{10}$ lbs. at $20 per lb. . . .	$68
Copper, 250 lbs. at 16 cts. per lb. . .	40
Value of one ton of fine washings, . .	$108

The value of the rock per ton is as follows. It yields in 50 lbs., silver 763·8 grs. = $1\frac{74}{100}$ oz.; equal to 4 lbs. 5 oz. 364½ grs. per ton; value, $87 25. Copper in 50 lbs. of rock, 6 lbs. 9¼ oz. = per ton 263 lbs.; value, $42 10. Value of one ton of the rock, $129 35.

Resumé.—In the rock the value is $129 35 per ton.

In the coarse ore,	silver = $500	copper, = $201
In the fine washings,	" = 68	" = 40
	Silver, $568	Copper, $241

Total value of one ton of clean metal, $809.

It is to be observed that the large sheets of copper which occasionally occur in the crevices, are not considered in this account; and since they probably will be found not unfrequently in the mine, they will go to augment the value of its produce.

The best flux for the fusion of the fine washings, which will be smelted at the mines, is carbonate of lime or calcareous spar, which makes, with the ferruginous trap rock, a perfectly liquid glass or slag, through which the metallic alloy of copper and silver quickly settles. The proportion of silver in the metal, reduced in the furnace, varies from 5 to 16 per cent. according to the nature of the ore. The average yield of the rock when assayed in the crucible with limestone and charcoal, is $7\frac{4}{10}$ per cent. of metal; and the metal analyzed yielded 94·864 per cent. of copper, and 5·136 per cent. of silver. The silver being worth \$102 50, and the copper \$15 17 = \$117 67 for 100 lbs. of metal.

In the furnace operations there may be a loss of copper by mismanagement of the blast, or for want of skill in the workmen; but the silver, being incapable of oxidation in the fire, cannot be lost. By numerous experiments, we have ascertained that the best proportion of lime is about one third the weight of the ore, or if calc spar is used, about half the weight may answer. Even less than this would render the molten mass sufficiently liquid in a blast furnace, where the weight of the metal and the intensity of the heat render the assay much more easy than it is in crucibles. The calc spar of some of the localities on the Company's lands, contains a considerable quantity of native copper, with a little of the carbonate. This should be preferred as a flux, for the copper it contains will be saved.

The vein of datholite at Eagle Harbor will also make an admirable flux, and the copper it contains will add to the yield of the furnace; while the borosilicate of iron and copper mixed with it, being saturated with oxide of copper, will not take up the metal in fluxing the ore. I have used it with advantage in some of my experiments, and find it to work perfectly well.

Art. XI.—*Practical Observations on the Generation of Statical Electricity by the Electrical Machine;* by Lieut. George W. Rains, U. S. A., Acting Assistant Prof. of Chem., Min. and Geol., U. S. Military Academy.

Having experienced, at different times, some difficulty in causing an abundant and uniform supply of electricity to be generated, by the apparatus employed, when the state of the air and other circumstances appeared entirely favorable, sufficient inducement was offered to devote a few leisure moments to the study of the causes of failure.

In completing a course of experiments with this object in view, results have been obtained in the excitation of statical electricity, deemed of sufficient value to merit attention. The invention of electrical machines being of such long standing, and the subject having received the attention of so many eminent persons, the writer, with some hesitation, ventures to suggest ideas derived from his own observations. The improvements proposed, however, being few in number and of simple application, he has thought proper to state them, allowing each one who may feel interested, an opportunity of satisfying himself of their utility.

Rubbers.—Commencing with the rubber of the machine, as the supposed principal source of failure, it was proposed to ascertain, first, its mode of action ; second, that substance which would be most efficient in its action.

In regard to its mode of action, the questions which presented themselves, were—does it produce electricity by friction, by chemical action, or by friction and chemical action?

Assuming at first that the effect is produced by friction, its mode of action appears to be as follows. The rubber touches the glass at any given moment with a certain number of its parts or points, and does not, therefore, come into contact with the remainder; the friction of these points generates the two electricities,* of which the positive remains with the glass, and the negative with the rubber. At the succeeding moment, the excited parts of the glass have passed opposite to those points of the rubber which do not touch; an inductive action then takes place—the positive electricity of the rubber is repelled, and the negative attracted, by the excited portions of the glass. If the negative electricity produced by the first action, has remained with the rubber, it will then be in such excess at the points in question, as to force itself through the thin intervening stratum of air, and neutralize the corresponding positively excited points of glass.

Hence to remove the negative electricity is of the first importance; and the necessity of being freed from it was perceived in the earliest experiments. Should this be accomplished, however, as perfectly as possible, it is evident that a diminished similar effect would necessarily take place, rendering neutral a quantity of electricity already excited. What has been observed of the situa-

* It is not intended to assume that electricity is *one or more fluids,* but the ordinary language is used for convenience.

tion of the points of the glass and rubber, at the first and second consecutive moments of action, evidently continues during the entire period of operation.

From what has preceded, two primary objects are to be attained: first, to determine the best method of disposing of the negative electricity of the rubber; second, to obviate the injurious effects of those of its parts not in contact with the glass.

To attain the first object, it naturally suggests itself to conduct it off by forming a communication with a conductor between the rubber and earth; and consequently, the directions given, and carried out in the construction of the best electrical machines, have been, to form a metallic connection with the *back* of the rubber, and the surrounding conducting objects. The idea appears not to have occurred, that such communication should be made with the metallic *face*, in place of the back of the rubber. The cushions being made of non-conducting materials, as silk or leather, stuffed with similar substances, the faces of the rubbers are insulated, and the negative electricity is prevented from escaping freely. This insulation is so complete in some rubbers, that with a twelve-inch plate machine scarcely the smallest quantity of electricity could be obtained, until the amalgam faces of the cushions were connected by a wire with the floor, when its amount was suddenly and greatly increased. It has been interesting to observe the numerous near approximations to this result, which, however simple, appears not to have been exactly hitherto attained;—the nearest approach, probably, being the suggestions to stuff the rubbers with elastic fragments of metal,* and the proposition to moisten their interior substance.†

Electrical excitation, in all descriptions of apparatus made use of for that purpose, will be increased by adopting the preceding suggestion. Should the amalgam faces of the rubbers be connected with the exterior coating of a Leyden jar, in the act of being charged, the effect would be much more satisfactory—the positive electricity of the coating neutralizing the negative of the rubbers.

The first object having been thus obtained, it remains to pass to the second, viz. to obviate the injurious action of those parts of the rubber not in contact with the glass. For this purpose, it is plain that if a non-conducting substance be interposed between

* Am. Jour. Sci. and Arts, Vol. xxiv, p. 256. † Franklin's Letters.

them and the excited glass, the desired result will be obtained; and the question resolves itself into the proper manner of applying the best substance. If an oxidizable metal or amalgam be employed, the oxide which is formed will answer this purpose itself, to a certain extent, as the oxides of the metals are imperfect conductors. For this purpose the oxygen of the air is of service. The prominent points in such cases will be kept bright by the rubbing of the glass. The oxides thus formed, continue to increase in most cases, particularly with the amalgams, and ultimately fill up the intervals; then sustaining the pressure of the glass, all farther action of the exciting points of the amalgam ceases: in such cases, the surfaces of the amalgam require renewal. The oxides, as will be seen hereafter, are but feeble generators. Tallow, lard, and substances of a similar nature, answer the purpose much better, and hence they were soon discovered to be of service in the earlier researches of electricians. The tallow or lard being spread over the surface, or mixed up with the amalgam, surrounded each exciting point of the rubber with a non-conducting medium, and hence fulfilled the required conditions. As, however, these substances readily combine, mechanically, with the metallic oxides, forming a black, adhesive mass, which collects on the glass, soiling its surface, and is troublesome to remove, bees-wax and shellac were substituted, both of which substances, when properly applied, answer the purpose remarkably well. Neither of them soils the glass, and what is of much importance, they give rubbers permanent in their action.

The question now arises, whether there be not other parts of the rubber, besides those surrounding the exciting points, which may have an injurious effect? That portion which precedes the first exciting points at the entrance of the glass, obviously can do no harm, as the glass is supposed not to be excited when passing in their vicinity; but the case is materially different with the opposite termination of the rubber, which, not being pressed against the glass, is highly injurious—abstracting largely from the electricity previously generated. This has also been observed by electricians, who do not, however, appear to have proposed any substantial remedy; the best hitherto given, apparently, depends for its success on the *regularity* of the pressure;* and still another plan which is liable to the same difficulty.† The silk flap, whose

* Partington's Nat. Phil., p. 151. † Nicholson, Phil. Trans., 1789.

utility appears to have been discovered by accident, and whose real object seems to have escaped attention, has succeeded or failed, as chance regulated its proper or improper application. A certain quantity of electricity is doubtless produced by the silk, in whatever manner it may be applied, and the amount is considerably increased by particles of amalgam which adhere to its surface; but the total quantity thus produced is small compared with that given by the rubber, and a larger amount will be obtained by removing the flap and increasing the pressure, so as to bring as many new points in contact as will equal by their friction that of the silk. Hence the above cannot be its true value, neither *did* its utility appear to depend, principally, on its being an interposed non-conducting obstacle between the excited glass and the molecules of air; but rather, having been fastened to the loose edge of the amalgamated leather, this edge was pressed against the glass by the adhesion of the silk, and thus prevented from diminishing the amount of electricity already evolved. It possesses, also, to some extent, the power of preventing the electricity of the surface of the glass from being drawn off or neutralized by surrounding objects. In modern machines, the rubbers are hair-stuffed cushions without the loose leather, and the flap is of varnished silk, which is so arranged, in some plate machines, as not to touch the glass. The first and principal advantage of the silk is thus lost, but the second more certainly obtained.

From what has been stated, it appears to be important to cause that edge of the rubber which the glass last leaves in its revolutions, and which is covered with amalgam, to press constantly and firmly against its surface. This is best secured by making use of a leather strip, covered with the amalgam, whose edge in question shall be firmly pressed between the glass and cushion, and which is consequently narrower than the latter. The idea now suggests itself, that in thus contracting the rubbing surface, its action may be lessened; hence, the proper dimensions for the rubber are next to be determined. To solve this proposition, requires a further investigation into the phenomena of excitation.

Statical electricity has been assumed to be produced by friction, and hence the result of molecular disturbance. Taking one of the exciting points of the rubber, resting on a corresponding portion of the glass surface; suppose such portion of the glass to move through an indefinitely small space; molecular disturbance will then be produced, both in the exciting point of the rubber and in the corresponding portion of glass surface; by hypothesis, the molecular vibration of the rubber producing negative, and that of the glass, positive electricity, each within itself. If it be supposed that the portion of the surface of the glass, in this indefinitely small movement, has continued in contact with the exciting point of the rubber, then the two electricities, respectively generated in each, will combine or interfere, and a neutral state will be the result whilst such contact continues. But should this portion of glass in its further movement pass beyond the exciting point, its molecular vibration continuing for a certain period, will evolve an additional quantity of positive electricity, which will remain after the molecular vibration has ceased; and this portion of glass will be electrically excited. Should the movement be still further continued, and this excited part brought into contact with the consecutive exciting point of the rubber, its electricity will, by the influence of this point, be nearly if not entirely neutralized. For otherwise it is difficult, if not impossible, to conceive of the evolution and absolute contact of the two electricities, at such point, without combining or interfering.

This view of the subject being taken, it follows, that only the last exciting points of the rubber produce the effective result. This, on first appearance, is a startling conclusion, as it apparently reduces the rubber to a mathematical line; on examination, however, this is found not to be the case; there must be a certain number of these last exciting points, in each of several consecutive parallel lines, as the points necessarily have spaces between themselves; hence a portion of electricity excited on the glass may pass between several, before it emerges entirely from the rubber. It follows, therefore, that a certain breadth of rubber is necessary, although it must be comparatively small. With rubbers, properly constructed, as will be described hereafter, the maximum effect for the larger machines, was produced by rubbers *one fourth of an inch* in breadth; and for the smaller, *one eighth of an inch;* the smaller rubbers having generally a greater pressure.

To determine the above, as well as to ascertain and confirm all other results given in this paper, a numerous set of experiments was instituted, by means, principally, of three machines. One was a glass plate of 12 inches, previously alluded to; one a cylinder of 10 inches diameter and 15 inches long; and lastly a large and beautiful instrument of 38 inches plate, manufactured in Paris. To measure *accurately* the quantity of electricity in each case, one of those admirable galvanometers of 3000 turns of wire, constructed by M. Goujon of the Polytechnic School, Paris, was employed; the amalgam of the rubbers being connected, by means of a copper wire, with one extremity of the coil, the other extremity communicating with the prime conductor, by means of a glass tube containing water, having a wire inserted in each end. The maximum *permanent* deflection of the needle by the 12 inch plate was 16°.

Having thus attained, satisfactorily, the two objects proposed, the discussion will be taken up on the questions first suggested, viz. is statical electricity produced by friction, by chemical action, or by friction and chemical action? The solution of the first two solves the third. To this branch of the subject, it was not considered necessary to devote much attention; for the results obtained by others, superior to the writer in abilities, have decided quite conclusively, that chemical action does not produce the excitement of the electrical machine. Indeed it is difficult to conceive, how ordinary chemical action in the amalgam of the rubbers, can influence the generation of electricity, except in the single case previously mentioned. For if it be supposed, that the surface of the amalgam is made up of numerous small galvanic circles, as is doubtless the case, the air acting, possibly in conjunction with its watery vapor, as the exciting medium; no action could be produced, unless such circles, either singly or collectively, were closed. Under the improbable supposition, that parts of the glass acted as conductors to complete such circles, it would be contrary to all analogy to suppose, that in their movement, they carry off a portion of such current. Neither can it be supposed, that it acts by inductive influence; as in such case, the induced electricity would be of a tension, so extremely low, as not to be apppreciable.

In order, nevertheless, to satisfy any existing doubt, a tube electrical machine was constructed,* whose piston performed the part of a rubber; and the apparatus arranged, so as to admit of being filled with different gases. It was thus found that air, oxy-

* American Journal of Science and Arts, Vol. XXVI, page 111.

gen, nitrogen, and carbonic acid gases, when thoroughly dry (and a vacuum) produced nearly the same amount of electrical action, when the same oxidizable or non-oxidizable rubbers were employed; hence this result coincides with that obtained by others.* The conclusion is therefore adopted, that the electrical machine produces its effect entirely by friction.

The second branch of the subject will now be examined, viz. to ascertain what substance is most effective, in generating electricity by friction. In the endeavor to attain this point, numerous experiments were made with various substances: a list of some of them is given, arranged according to their effective actions.

1. Bisulphuret of Tin and amalgam.
2. Common Amalgam.
3. Pure Mercury.
4. Bisulphuret of Tin.
5. Tin foil.
6. Zinc filings, (fine.)
7. Copper filings, (fine.)
8. Silver.
9. Gold.
10. Platina.
11. Lead.
12. Caoutchouc.
13. Silk.
14. Paper.
15. Leather, (soft.)
16. Woolen.
17. Plumbago.
18. Iron filings.
19. Antimony.
20. Bismuth.
21. Galena.
22. Talc.
23. Chromate of Iron.
24. Protoxide of Copper.
25. Protosulphuret of Mercury.
26. Chromate of Lead.
27. Protoxide of Bismuth.
28. Peroxide of Manganese.
29. Peroxide of Mercury.
30. Protoxide of Zinc.
31. Protoxide of Mercury.
32. Protoxide of Tin.
33. Shellac.
34. Wax, (no action.)
35. Tallow, "
36. Lard, "
37. Bisulphuret of Mercury with lime, gives negative electricity.

From the preceding, it appears that bisulphuret of tin rubbed over a surface of amalgam, containing but little mercury, is the most efficient of all substances employed; it is, however, inferior in value to the common amalgam, on account of its transient ac-

* Dans la production de l'éléctricité par frottement, l'action de l'air sur les enduits, plus ou moins oxidables des frottoirs, ne parait exercer aucune influence sur les effets électriques qui en resultent.—*Peclet's Memoirs.*

tion, requiring frequent renewal; and the quantity of electricity evolved, soon being but little more than that capable of being produced by the amalgam itself. The amalgam, in case the sulphuret is employed, acts principally, by serving as a metallic communication to convey off the negative electricity, as rapidly as generated. Tin or copper filings answer the same purpose, nearly as well as the amalgam.

Hence the common amalgam has been selected, as the most suitable material, on account of the quantity of electricity produced, as well as its ease of application; and, when properly applied, the valuable steadiness of its action. Its composition is but of little importance, equal parts, by weight, of zinc, tin, and mercury, answering every purpose. The zinc and tin are to be melted together, the mercury then added, and the melted mass poured into a wooden box, and agitated violently until cool; then it is to be still further reduced to a fine powder, by being rubbed in a mortar. The various results obtained by different electricians, each recommending a new proportion of ingredients, appear to have been caused by the different conducting powers of the cushions of the rubbers employed; they having failed, probably, in each case to connect the metallic faces with the earth.

It will be observed that the oxides of zinc, tin and mercury, yield but a small comparative quantity of electricity; hence the necessity of frequently renewing the amalgam of the rubbers, constructed after the ordinary method. The combination of mercury with the common metals, being rapidly oxidized by reason of the galvanic action, shows the reason why "amalgams containing much mercury are of transient and variable action."*

It is probable that pure mercury, if it were possible to apply it, so as to cause as much friction between its particles and the surface of glass as takes place with other metals, would surpass all other substances in its effective capabilities. This, however, is impossible as long as it continues fluid, on account of the mobility of its particles; and this mobility constitutes its chief value, by allowing a more perfect contact with the glass; hence its maximum effect can be approximated to, only by rendering it semifluid, in forming an amalgam.

The number of rubbers to be employed demands some attention, and at the same time the action of the double rubbers, of

* Singer's Treatise on Electricity, page 52.

the plate machines, will be examined. Theoretically, the number of rubbers is unlimited; for if one produces a certain effect, six would produce six times that effect, if the electricity be removed as rapidly as evolved; but in practice, the number is necessarily limited, and this limit depends, collaterally, on the size of the plate or cylinder, and the convenience of construction. Cylinder machines have but one rubber, which arrangement may have had its origin, in the larger machines, merely from the slightly increased difficulty of construction. This arrangement necessarily lessens their power one half.

Plate machines have generally two pairs of rubbers, or four in all; in large plates, this number might be increased to three or four pairs, with corresponding increase of power; but the labor of working the machine would increase in the same ratio; which, in this kind of machines, is a material circumstance. However, with rubbers constructed after a manner to be described, the labor caused by two rubbers, is but little greater than that caused by one, of the common construction.

The action of double rubbers will now be discussed. A single rubber evolves a certain quantity of electricity; one surface of the plate being thus excited, the inductive influence causes a certain amount of positive electricity to become free on the opposite face; which acts also by its induction on that of the opposite surface, and increases its amount; and this action and reaction between the surfaces, continue until an equilibrium is established; the result being, that with the ordinary glass plates the original electricity generated is nearly doubled in its amount. If in this condition, the positive induced electricity of the second surface be removed, it will leave the corresponding quantity of negative electricity on this surface of the glass, which will neutralize the opposite positive surface; and nearly all signs of excitation, on such surface, will consequently cease. By continuing this process, the second surface of the glass gradually ceases to give off electricity; and the quantity generated on the first surface, not being increased by induction, becomes comparatively feeble in its action. The plate has now become charged, in a manner similar to that in a Leyden jar; and if removed and placed on a ring of metal, a corresponding ring being then placed upon it, and opposite to the first, by forming a connection between the two, a strong discharge will take place, and the plate resumes its first condition.

From the preceding, the following conclusions are drawn: 1st, the quantity of electricity generated by the rubber with the common glass plates, has its amount nearly doubled by inductive action; 2d, to maintain this increased effect, it is necessary that the induced electricity of the second surface be allowed to remain on that surface. The inductive action being a decreasing function of the distance, it follows, that the thinner the glass, the greater will be the effect; which indicates the value of the first conclusion. From the second, it appears, that if a cylinder have a damp interior surface, its effective action will be much diminished; all cylinders should, therefore, have their interior surface perfectly dried, and then be sealed up air tight. If varnished with shellac, which has not been colored by the addition of any other substance, the cylinder, after having been once dried, may remain open without material injury to its generating powers.

The machine being in action with one rubber, it will be supposed that a similar one may be arranged to the second surface of the glass, and diametrically opposite to the first rubber. A certain quantity of positive electricity being generated by the second rubber, it will find itself in contact, and will unite with, the similar electricity induced on that surface of the glass, by the action of the first rubber. Hence the amount on this surface will be much increased; and this additional quantity, acting inductively on the first surface, will likewise increase its excitation; the final result being, that the electricity produced by the rubbers, on each surface of glass, is nearly doubled by inductive influence.

It may at first appear, that by arranging points to each surface of the glass, nearly four times the quantity evolved by one rubber might be collected; on a closer examination, however, it will appear that but little more than one half of this amount can be rendered available; for as soon as the free electricity of one surface is removed, that of the other, to a great extent, becomes necessarily neutralized. The plate acquiring a charge, similar to that produced in the experiment of the single rubber, although to a much less extent; and as the plate revolves, passing between the connected metallic faces of the rubbers, this small charge is neutralized.

It has been so far assumed, that the rubbers were placed diametrically opposite; allowing one to retain its situation, the other will be supposed to change its position. A certain quantity of induced positive electricity being evolved on the second surface of the glass, by the action of the first rubber as already discussed; this passes with the glass surface in its revolution, to the metallic face of the second rubber, where it necessarily becomes absorbed by the negative electricity of that rubber, and the free positive electricity, generated by the first rubber on the first surface, is thus, to a great extent, rendered neutral. If the metallic faces of the two rubbers be in connection, as is the supposition, the glass surfaces will thus be brought back nearly to their primitive state, and the product of the action of the first rubber ceases almost entirely to exist.

It follows from this, that it is important that the rubbers be placed opposite to each other; a *slight* variation is not, however, very perceptible, by reason of the vibrating molecules of the glass, continuing to produce positive electricity, after passing to a certain distance the exciting points of the rubber. That this is a correct hypothesis may be shown by the following experiment: let the back of the hand be held near the second surface of the glass plate of the machine; on rubbing the opposite surface with a piece of silk, every motion of the rubber, will be distinctly and *instantly* perceived; hence, if the electricity of the surfaces ceases to be generated, when the portions of glass pass beyond the exciting points of the rubbers, it follows, that if one of the rubbers be somewhat in advance of the other, the electricity induced by the remaining rubber, will be mostly absorbed, and the practical action of this rubber destroyed, which for a slight variation is not the case.

The length of the rubbers will now be determined. In cylinder machines, the rubbers should extend so as to rub the entire exposed surface of glass; the ordinary practice of limiting their length to a portion of the surface, appears to be deficient in principle. For, let it be supposed that such is the case; then those parts of the exposed glass surface, not subjected to the rubbing action, hence not yielding electricity, must conduct off a small quantity of that produced elsewhere. But should the rubbers extend to the axis, an additional quantity will be evolved, and if the axis abstract a portion, on account of its proximity, it will be but a small part of this additional quantity. It cannot be supposed, that in exciting those portions of the glass near the axis, the glass itself becomes a better conductor.

It is important that the elements of the glass, subjected to the action of the rubbers, be as long as possible; for the glass surface may be considered as composed of an indefinite number of consecutive portions, and as each one of these portions, when excited, acts inductively on those around it, it follows, that the greater the number excited at the same time, the greater must be the reciprocal inductive influence. Hence large machines, when under the same circumstances, must give electricity of a higher tension, than that produced by smaller machines.

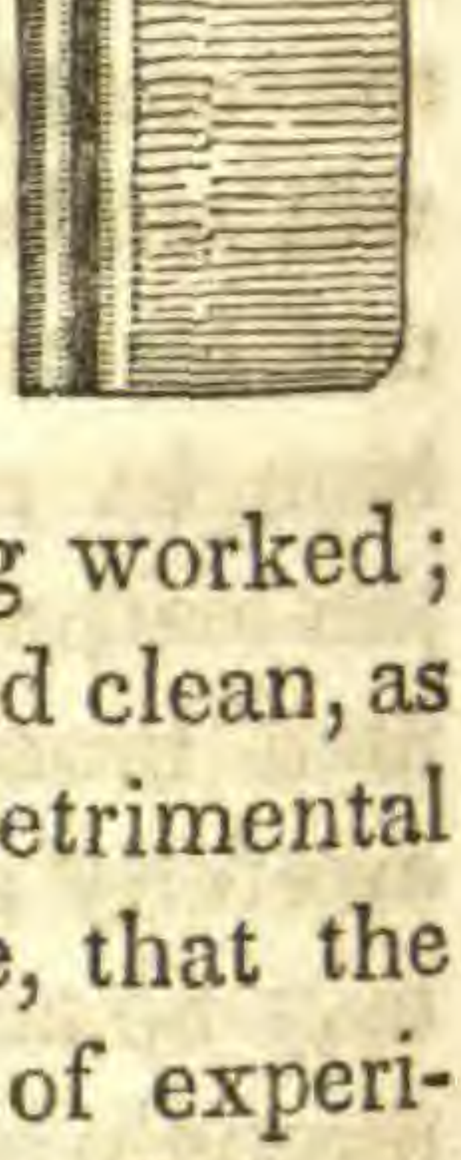
Having thus discussed the principles of action, of the various parts of the rubber, it remains to apply them practically. To obtain the narrow strip of rubber, requires the following process: being provided with a strip of common amalgamated leather, subject it to strong pressure, in order to render the surface flat and smooth; it is then to be rubbed with a clean cloth, to remove any excess of lard or tallow, if such substances be employed;* which must still further be removed from the exciting points, by rubbing the amalgam with a piece of smooth leather dipped into mercury, to which a few particles will adhere; this not only cleans the exciting points, but enlarges their extent.

If the amalgam be now applied to the glass with pressure, those portions of the surface still covered with the lard or tallow, might come into contact at some points with the surface, and produce a detrimental effect; to avoid this, reduce some plumbago (black lead) to a fine powder, which is to be rubbed over the surface of the amalgam, and by adhering to such portions will render them excitable points. It also permits greater pressure for the same amount of friction; and thus the surface is brought more intimately into contact with the glass. From the leather prepared as above described, a strip one fourth of an inch broad, and somewhat longer than the rubber, is to be cut; carefully avoiding to break up the amalgam at the edges, which may be accomplished by covering it with pasteboard and cutting through both substances.

The rubber proper being prepared as above directed, it remains to apply it to the cushion, which, to avoid unnecessary resistance, should be *three quarters of an inch* or *one inch* in breadth, and this last dimension should not be exceeded in the largest machines.

* Wax and shellac, as previously stated, may be used with advantage, but they require more care in the manipulation.

The cushions should be made quite firm, and not stuffed with hair, as that does not allow them to offer sufficient resistance; they should be as perfect non-conductors as possible; the backs of the cushions should be of glass or well-baked wood, in order to prevent the cushion from abstracting a portion of the electricity generated by the rubber. A piece of smooth white leather, about three times the breadth of the cushion, should be fastened by one of its edges to the glass or wooden back of the rubber, and passing over the face of the cushion, will thus be pressed against the glass, the remaining edge being loose. This flap of leather should not be very thin, otherwise there will be a useless adhesion to the glass, increasing the amount of friction unnecessarily; it should be kept *perfectly dry*, as the entire action of the machine, be it ever so powerful, will be destroyed should it become damp on the surface opposed to the glass. To this leather flap, and opposite to the centre line of the cushion, fasten the strip of amalgamated leather by means of a little warm bees-wax; the face of the leather will then exhibit the appearance as shown by the adjoining figure: the projecting end of the rubber proper being left, for the purpose of forming a metallic communication between it and the exterior coating of a Leyden jar, or with the earth.



To obtain the *maximum* effect, those portions of the leather flap on each side of the amalgam strip, which are pressed against the glass by the cushion, should be touched with a little bisulphuret of tin, which, in the larger machines, will be found to increase powerfully the action; it requires to be renewed, however, every twenty minutes, whilst the machine is being worked; at each of which renewals, the amalgam should be wiped clean, as the sulphuret of mercury, which may be formed, is detrimental in its action. It may be well to observe, in this place, that the glass should be oiled and *wiped clean* before a course of experiments, to prevent its surface from attracting moisture.

The rubber being finished, it must be thoroughly dried to expel any moisture, before being applied to the machine. The ordinary degree of firm pressure, employed in the common-sized machines turned by means of a crank, has been found to produce nearly the maximum degree of excitement; any increase of pressure above this limit, although generally followed by an increased quantity of electricity, is inexpedient, as the additional amount thus evolved, does not compare with the increase of friction; between zero of pressure and this limit, however, the quantity generated is directly proportional to the friction or pressure.

Large plate machines, as will be seen hereafter, admit of less pressure on equal surfaces than cylinders, and consequently are less effective, as the limit above alluded to is not attained.

Plates and Cylinders.—It is now proposed to examine into the comparative qualities of plates and cylinders, in order to determine their relative values as electrical generators.

If an unpolished glass surface be employed, with an amalgam rubber, the electricity generated on the glass will be negative; if it be partly rough and partly polished, the rough parts will give out negative, and the polished positive electricity; if equal in extent, they will neutralize each other's action, and no effective result will be obtained. As the polished surface increases in extent, the rough surface decreasing in the same ratio, the positive electricity acquiring the ascendancy, will increase in quantity until the glass becomes entirely polished, when its intensity will be at a maximum. It follows from this, that the fineness of the polish is a necessary qualification. Inequalities in the surface lessen the effect, by reason of the depressions not being acted upon properly by the rubber; hence the surface should be ground smooth before polishing. The glass should be kept perfectly clean; as any substance adhering to its surface would cause the rubber to act on that in place of the glass, and by hypothesis, a diminished result would be obtained. Should such substance be taken from the rubber, it carries with it a portion of its negative electricity, thus neutralizing a portion of the positive surface.*

From what precedes it appears, that plates have the advantage of admitting a finer polish and more uniform surface than cylinders; which latter, however, are usually thinner, and therefore the inductive action is stronger. It will be supposed that the advantages of each are in these respects balanced; it remains to compare their powers. For this purpose, a plate of thirty six

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* Que lorsque l'un des corps soumis a l'expérience est entamé par l'autre, celui-ci, outre, l'électricité qui lui est propre, prend encore, avec la petite couche mince de la substance qu'il enleve, une portion d'électricité propre à cette dernière; de sorte que la sienne se trouvant modifieé, peutêtre positive, nulle ou négative.—*M. Becquerel, Vol. II, p.* 122.

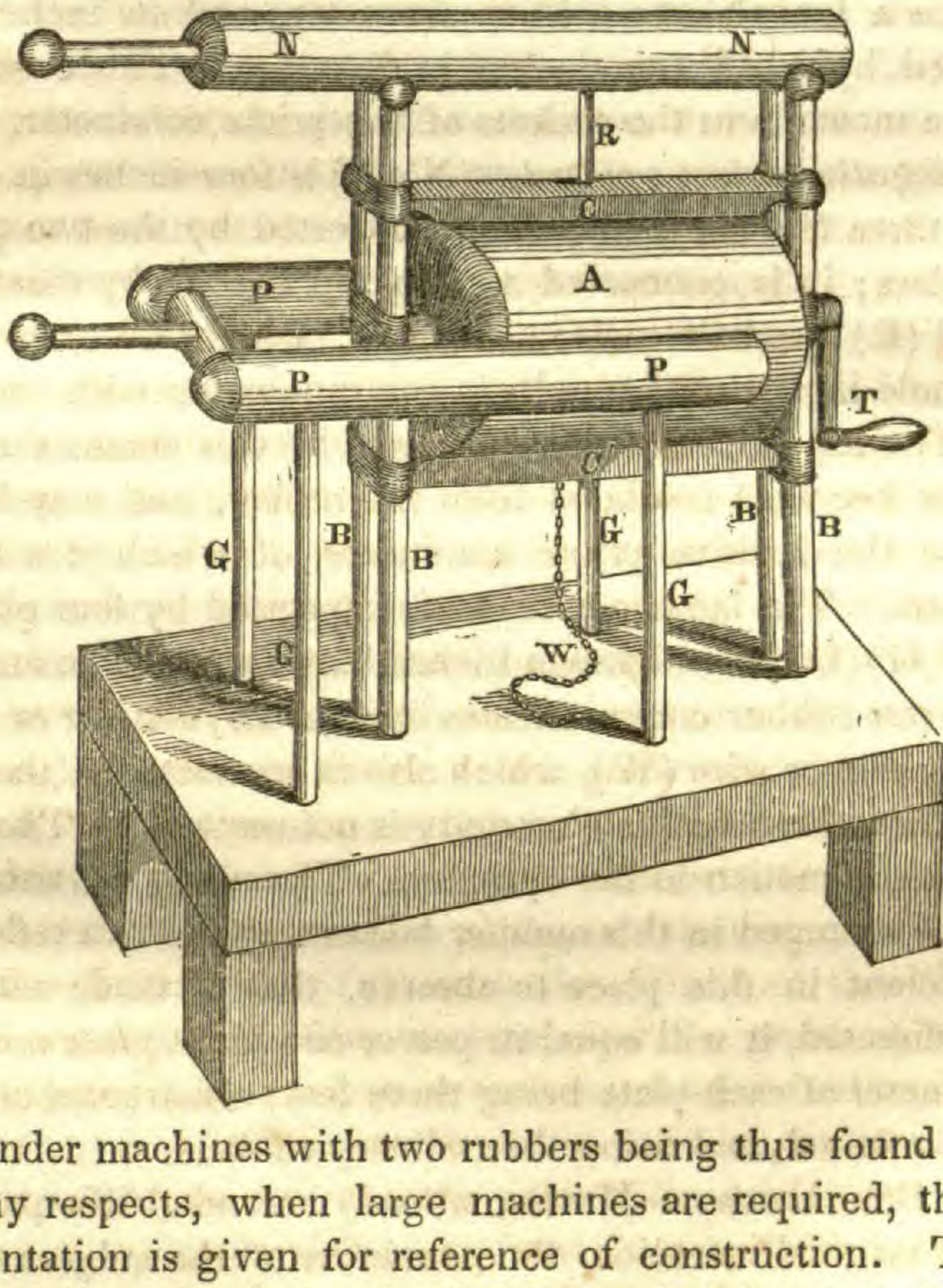
inches diameter, with four rubbers twelve inches long each, will be compared to a cylinder of twelve inches diameter, and eighteen inches long, with *two* rubbers eighteen inches long each. As the velocity of the portions of the glass passing under the rubbers is an increasing function of their respective distances from the axis of motion, the velocity of the circumference of that circle, which touches the centres of the cushions, will be taken for the mean; and this, multiplied into the total length of rubber, will represent the amount of glass surface subjected to the rubbing action for one revolution. Hence,

Inches.
(37·6992)48=1809·5616 for one half revolution of the plate.
(37·6992)36=1357·1712 for one revolution of the cylinder.

It is assumed that the amount of force expended in each machine for each unit of time is equal; hence but one half of a revolution of the plate is considered; for the diameter of its mean circle of resistance being twice the diameter of the cylinder, it follows that the plate will make but one half of a revolution, whilst the cylinder performs one entire revolution. Friction being directly proportional to pressure, it is evident that the sum of the pressures in each machine must be equal: hence the same amount of pressure is exerted on forty eight inches of rubber in one case as is applied to thirty six inches in the other; an inch of each is then pressed in the inverse ratio of these numbers, or as 3 to 4. But by hypothesis, the greater pressure produces the maximum effect; hence each inch of the plate rubbers does not exert its greatest action; and as it has been assumed, that up to the maximum pressure for the same extent of surface the disengagement of electricity is directly proportional to the friction, it follows that the quantity given out by each inch of the rubbers of the plate, is to the quantity given out by each inch of the rubbers of the cylinder, as 3 to 4. But each of the rubbers of the same machine produces, by hypothesis, an equal effect on each equal portion of glass surface subjected to its action; hence is obtained, for the total effective action for a unit of time of each machine, as follows:

(1809·5616)3=5428·6848 for the plate machine.
(1357·1712)4=5428·6848 " " cylinder "

The machines are therefore equal in power. This result has been confirmed by accurate experiment. It is conceived that the variety of opinions expressed on this subject has proceeded from the use of but one rubber to the cylinder, and from inattention to the proper method of carrying out the details of construction. It results from the foregoing discussion, that for *large* machines the cylinders are much to be preferred, for economy of construction, occupying less space, being less liable to accidents, and for the convenient collection of the negative electricity. Plates are preferable for small machines, by reason of being more compact as well as of finer appearance, and on account of the interfering action of the points of the prime conductor, which emit sparks to the rubbers if too nearly approximated.



Cylinder machines with two rubbers being thus found superior in many respects, when large machines are required, the above representation is given for reference of construction. The *cylinder* (A) is twelve inches in diameter and eighteen inches long; it is supported by two pairs of glass pillars, (B)(B), (B)(B), one and a quarter inches in diameter each, and three feet long; or of one half this length, and joined together at the axis of the cylinder by brass tubes four inches in length; these tubes being connected by a cross piece, furnish supports to the axis which turns between the glass pillars; these are placed one inch apart.

The *rubbers* (C) (C′) have glass backs one inch broad, and one and a half inches deep, and are about two feet long, moving between the glass pillars, which, by means of brass caps or sockets and screws, cause the rubbers to maintain the proper degree of pressure.

The *positive prime conductor* (P) (P), is composed of two branches, one on each side of the cylinder, each of which is four inches in diameter, and three feet long; these are joined at their farther extremities by a cross tube of two inches in diameter, which has a branch one inch in diameter, and six inches long, terminated by a ball two inches in diameter. The cross piece should be movable in the sockets of the prime conductor.

The *negative prime conductor* (N) (N) is four inches in diameter, and three feet six inches long, supported by the two pairs of glass pillars; it is connected to the top rubber by means of a brass rod (R) one half inch in diameter, which is loosely inserted in a hole in the rubber which communicates with the amalgam. The rod can be withdrawn, and by this means the upper conductor becomes insulated from the rubber, and may be connected to the positive prime conductor, of which it will then form a part. The latter conductor is supported by four glass pillars, (G) (G) (G) (G), eighteen inches long each. The amalgam of the lower rubber communicates with a Leyden jar or the table by a chain or wire (W), which also is connected to the upper rubber when the negative electricity is not wanted.* The crank (T) gives the motion to the cylinder. The many advantages of a machine arranged in this manner become evident on reflection; it is sufficient in this place to observe, that if made after the manner directed, it will equal in power *two large plate machines* (the diameter of each plate being three feet) constructed after the common method, and using the ordinary rubbers.

Prime Conductors.—Having already extended this paper beyond the original intention, the remainder of the subject will be concisely treated. Prime conductors of the ordinary form should be of such size as to hold on their surfaces electricity of the same

* By applying a detached row of points communicating with the ground, and near to the glass between (A) and (C), both conductors will be charged at the same time,—one with positive and the other with negative electricity.

tension as that of the glass, without throwing any of it off. "This tension cannot be exceeded."* If of greater size, they are injurious by reason of their increased surface, presenting an increased extent to the conducting action of the air. If of small size, unless spherical, the excess of electricity is rapidly thrown off; in charging an electrical battery, however, they are preferable to those of larger size.

Prime conductors probably have the best form for common purposes when they are composed of two branches, each having a length double that of the cylinder, (or equal to the diameter of the plate,) and a diameter one fourth that of the cylinder, or one tenth that of the plate: connected by a cross piece one half the diameter of the conductors. Brass smoothly gilt is the best ordinary material; it should be neither varnished nor painted, for the sparks break through such coatings, leaving rough points, which are sometimes highly detrimental.†

The only part requiring particular attention on the subject of the prime conductors, is their *points* to receive the electricity of the glass. A common pin is about one inch long and one twentieth of an inch in diameter; let it be supposed that both ends are pointed and covered with little balls of wax; apply it to an excited body; it will receive a certain charge which has a tendency to escape, which tendency, for a unit of surface equal to that of the point of the pin, at the central portions, will be represented by unity. Remove the wax balls; the pin may now be considered a prolate spheroid, whose transverse axis is one inch in length, and its conjugate, one twentieth of an inch. But in such case the tendency to escape at the central portions of the spheroid, is to the same effort at the extremities, "as the square of the conjugate axis (1^2) is to the square of the transverse (20^2):"‡ hence the effort to escape at the point of the pin is represented by 400. Let it be now supposed that the pin retains its point but doubles its own diameter; the proportion will then be as 2^2 to 20^2, or as 1 to 100. Hence by doubling the diameter of the pin, it has diminished the power of its point to one fourth; this shows the importance of having slender points.

The influence of a point depends moreover on the tension of the electricity, and appears to act as follows. From the position

* M. Becquerel, Vol. II, p. 205.

† Faraday's Chem. Manip., note by Prof. Mitchell, p. 452.

‡ Murphy's Mathematical Discussions on Electricity, p. 69.

at which the point first shows signs of being acted upon, draw a cone of rays tangent to the exciting electrical atmosphere, having the point at the vertex; this cone of influence being formed of neutralizing rays, the intensity of their action, by the laws of induction, depends on the distance of the point from the exciting body. As the point approaches this body the elements of the cone, remaining tangent, diverge until having reached a certain degree of divergency depending on the intensity of the electrical action, they cease to separate; and if the point continue to approach the excited body, the cone will be intersected by this body. These intersections decrease in extent until the point touches the body, when its influence, except for the corresponding point in contact, ceases. For electricity of low tension, the point being that of a common sized needle, the limiting angle of the elements of the cone appears to be about 166°, which, if the point be at one fourth of an inch distant from a plane exciting surface, will intersect such surface in a circle, whose diameter is about four inches. The electricity within the circumference of this circle will be entirely neutralized. It appears therefore that the points of the prime conductor to collect electricity of *low* tension, should be needles, and placed not farther apart than four inches. The electricity on the glass surface on leaving the rubber, being of high tension, soon commences to be acted upon by the points of the conductor; its tension rapidly diminishes as it approaches the points, and when opposite, entirely ceases. The prime conductor however being insulated, and having acquired a certain degree of tension itself, refuses to accumulate any more electricity of the same or lower tension; the parts of the glass opposite to the points being thus in an excited condition, electricity of higher tension arrives nearer and nearer to the points at each revolution; its inductive action causes the elements of the cones of influence again to diverge, enlarging the areas of the intersections. The prime conductor and glass having arrived at the same electrical state, those points which find themselves in the most favorable positions, will receive the electricity having the highest tension, and the remaining points, in place of receiving, will give off electricity to those portions of the glass which may, from any defect, have less tension. It hence appears, that needle points should not be nearer to each other than four inches, to collect electricity of the lowest tension: as this however in most cases is almost instantly increased, five inches would answer a better purpose, in order to diminish the number as much as possible. In charging large batteries, an additional set of movable points might be employed, to be taken off as soon as the tension reached a certain extent. From the discussion of the action of the rubbers in plate machines, it will be concluded, necessarily, that but *one* permanent set of points to each double rubber should be employed, which may be on either side of the plate—a set for each surface being not only useless but injurious.

By applying the suggestions given in this paper to electrical machines of the common construction, it will be found as a general result, that those of the best construction will double their action, and that others will more than quadruple the amounts previously generated.

Thus has the subject of the ordinary excitation of statical electricity been as fully discussed and applied, as the small amount of leisure time at the disposal of the writer would admit; and although necessarily imperfect, it is still confidently believed to contain hints, which if acted on, will richly repay the electrical amateur.

Art. XII.—*Ruins of Nineveh: Description of the Discoveries made in* 1843 *and* 1844;—in a letter from Rev. Azariah Smith, M. D., Missionary A. B. C. F. M.

The city of Nineveh, so well known from the facts related in the book of Jonah, was one of the most ancient cities of which we have any record. It is mentioned in Genesis x, 11, and was probably founded within two hundred years after the flood. In its days of prosperity, it is described as having been a city of "three days journey;" i. e. say sixty or seventy miles in circumference, and as having contained 'more than six score thousand persons that could not discern between their right hand and their left hand; and also much cattle.' (See Jonah, iii, 3, and iv, 11.) Supposing this number to refer to children, the population of Nineveh could not have been less than 500,000, and from the mention made of cattle, it is probable that the city embraced fields within its limits, both for pasture and tillage. This 'exceeding great' city, at that time the capital of the Assyrian empire, was destroyed about the beginning of the seventh century before Christ, and, though afterwards rebuilt by the Persians, it never reattained its former splendor. In the seventh century of the Christian era, it was finally destroyed by the Saracens, and its name and its place would have been quite forgotten, but for the prominence given it by the records of inspiration. Indeed its geographical position has been so much involved in doubt as to render it a worthy subject of scientific inquiry, but the result of the observations of Rich and others has been to fix its locality on the east bank of the river Tigris, (called by the Arabs, Shat,) directly opposite the modern city of Mosul. There, ruined walls of sun-dried brick still remain, varying from fifteen to fifty feet in heighth, and enclosing a space about four miles long and a mile and a half broad; the whole of which is strewed with fragments of pottery and other marks indicating the site of an ancient city. Two immense mounds occupy each several acres of this area; one of them is about a mile and a half in circumference, and fifty feet high,—and the other, though smaller, is sufficiently large to contain upon its top and sides,—as it does at the present time,—a village of two or three hundred houses. The principal mosque of this village is said to cover the tomb of Jonah, and hence the village is called by the Arabs, Nebi Yunis, or the 'prophet Jonah.' On the east side of the enclosed space above referred to, there are *two* walls, at their southern extremity approximating, and at their northern about three quarters of a mile distant from each other. The outer of these appears to be the older one and probably remains from the Assyrian city, while the inner and more modern may have been constructed when the place was rebuilt by the Persians. Just within the outer wall, there is an artificial channel, several yards in width, cut, in some places, through solid rock, and in the enclosed space west of the inner, where are also the two mounds spoken of, foundations still remain, marking the site of buildings, and of arches, which, at different places, once stretched accross the Khausser,—a stream which passes through the ruins from east to west, and a half mile farther on empties into the Tigris. Several bricks and other fragments covered with inscriptions in the 'cuneiform character,' and one or two large blocks, having on them figures in bas-relief, have also been found, most of them in connection with one or other of the two mounds. All these ruins, together with the general locality of the place, the names of other towns in the vicinity, and above all the name (the prophet Jonah) given by the natives to the village on one of the mounds, has been deemed sufficient warrant for identifying this spot with that once occupied by the city of Nineveh.

The greatest objection which has been felt to assigning to these ruins this name, is the size of the area which the walls enclose; as this is much inferior to the area of Nineveh as described in history. Mr. Rich,* to meet this difficulty, suggests that the walls now standing represent only a palace and royal grounds, and that the populated part of the city was without this enclosure. As there is however no evidence of any wall enclosing such a city as this would suppose, the adoption of the view renders one of two conclusions necessary, viz. that the city was unwalled; or that, while the wall of the palace has been preserved, that of the city has been destroyed. Both of these conclusions are, in themselves, improbable; but independent thereof, there are many facts that seem to us to render his theory untenable. The fact that another wall enclosing an area, is found within the territory that such a city must have occupied, and that marks of edifices are rarely if ever found in the space lying between these areas, seems to us to decide the point. Moreover, no one can stand upon one of these ruined walls, and compare the rolling surface without, with the level area within, and the high mounds upon that area, especially as these and the space around them is strewed with fragments of pottery and other ruins, without feeling that he is standing upon the ramparts which separated the town from its cultivated fields. If, however, we are warranted by Jonah iv, 11, in supposing that the Nineveh of Scripture included gardens and pasture grounds for 'much cattle,' then it seems not unlikely that there may have been included under one name, two and even more distinct groups or suburbs of houses, each protected by a wall peculiar to itself. Unless we adopt some such view as this, how can we suppose a city of three days journey to contain only 120,000 persons who were unable to discern their right hand from their left hand. The view just proposed, moreover, derives support from the fact that Jonah (ch. iii, 4,) entered into the city a day's journey—i. e. according to this supposition, he passed through the gardens which contained only

* Residence in Koordistan and Nineveh.

scattered houses, and perhaps even by one or more enclosed suburbs to the main walled town—before he began to preach.

To remove objections to the view that Nineveh included more than one walled suburb, it may be well to mention some similar cases in modern times. In the single and small district of Tiyary, which lies sixty miles to the north of these ruins, there are no less than three instances of several villages grouped under one name. Rumpta, Kaylaytha and Berawola are villages composed severally of eleven, seven, and four distinct and *somewhat distant* groups of houses. By inhabitants of these places, each group is known, at least in the first two instances, by some specific title, but away from home the division is no more recognized as a valid ground for considering them distinct villages, than is the local division of Philadelphia, into Southwark, Kensington, Northern Liberties, &c., a valid ground for calling these districts, in general geography, so many cities. In Berawola this is more remarkable, as the groups of houses are separated by quite high and steep hills, and as, in this case, even the villagers among themselves seem to have no distinctive name for the several parts which go to make up the whole village. I refer to these examples, because occurring among a people (the Nestorians) living in the neighborhood of these ruins, and who, having long remained undisturbed,—perhaps even from the time of Nineveh's overthrow, in the inaccessible fastnesses of their barren mountains, are more likely than any other to have handed down to us unchanged, the customs of those times. Other examples of something similar, and more weighty, because better known, may be found in Beirout, Constantinople, and Trebizond. These are seaport towns with walls, but a large proportion of their population reside without them. Constantinople indeed has *enclosed* suburbs besides the main walled town, and if these were separated from it and from each other by gardens instead of water, they would exactly illustrate our idea of the places represented by the two ruined enclosures, spoken of as found on the east side of the Tigris near Mosul. The object of the remainder of this article, will be to give a brief account of the late discoveries of Mons. Botta, the French Consul of Mosul, in the more eastern and inferior of these ruins.

These discoveries were made in a mound about ten miles to the northeast of the village of Nebi Yunis. This mound is about four hundred and fifty feet wide, six hundred feet long, and varies from twenty to forty feet in heighth. Its area is nearly oval, but its surface is somewhat uneven, and its outlines are correspondingly irregular. It is situated in one side of what appears to have been a fortified town, (or suburb ?) there being still in existence the remains of a mud wall, enclosing a space a mile square. This ruined wall is in few places,—and those apparently towers, —more than ten feet high, but as there is evidence that it was originally faced with hewn stone, no doubt can exist but that it was built for purposes of defence, and once enclosed a thriving, busy population. But to return to the mound referred to, and which forms, by one of its faces, a part of the northeastern boundary of this enclosure. It has been occupied as far back as modern inquiry can extend, by an Arab village of about a hundred houses, called by the natives Khorsabad. In digging vaults or cisterns for the safe deposit of straw and grain, these people had repeatedly found remains of ancient sculpture, but their value not being known, no account of the discovery was made public. In 1843, while Mons. Botta was making excavations in one of the mounds near the Tigris, one of the villagers of Khorsabad inquired of him why he did not come and dig in their village, "for," said he, "it is built on a mound like this, which contains more beautiful stones than any you can find here." In due time the work of excavation was transferred according to the villager's recommendation, and the step resulted in one of the most interesting discoveries, if we may not say the most interesting discovery of modern times. The whole upper part of the mound has been found to be threaded with walls running at right angles to each other, and enclosing rooms varying from thirty to a hundred and thirty feet in length, and pretty uniformly about thirty feet in breadth. The whole seems to have been but a part of one building, and perhaps but a small part, for the walls are broken off in several places by the edge of the mound in a manner which indicates that its area was once much more extensive than it now is. But we will not venture into the field of conjecture; our object is to describe what has been actually discovered.

The point where the excavations were commenced was near the margin of the mound, about twenty feet above its base, and where the top of what seemed to be a stone wall presented itself. On digging along the sides of this, it was found to be composed of a single row of large hewn stones, the top of which had been broken off by violence or otherwise destroyed. On one side these stones were plain or unfinished, on the other the lower part of the legs of captives, with chains around their ancles, were represented in bas-relief, the latter being the surface designed to be seen, while the former was contiguous to an unburnt brick wall, of which these stones formed the facing. To furnish a good opportunity to examine and copy these figures, a ditch about four feet wide was dug along in front of the stones, sticks being so placed as to keep them from falling forward. Following the stone work in this manner a little distance, the workmen came to a doorway. Turning around the corner thus presented, they directed the digging inward towards the room, and the walls were found to have been twelve or fifteen feet thick. The doorway thus entered was about eight feet broad, and its floor was formed by a single stone, which was covered with writing in the cuneiform character. On the stones forming the sides of this doorway were immense figures, having an eagle's head and wings, with arms and legs like those of a man. The doors were gone, but circular holes, about ten inches in diameter and as many in depth, were found cut in the floor on each side of the doorway. These holes were so situated in the angles of recesses in the sides of the doorway, as to leave no doubt that they were the reçeptacles of the pivots on which the doors turned. Those who are familiar with the manner in which the lock-gates of American canals are usually hung, and the recesses into which they fit while boats are passing in and out of the locks, will derive from them a very correct idea of the style of the doorway just described. This doorway being cleared out, the digging was directed along in front of the stone, facing the inner side of the unburnt brick wall. In this way, also, the excavations were conducted throughout the whole of the work, which comprised a line of stone facing, ten feet high when the stones were uninjured, and, following its ramifications, more than a mile in length; the whole of which was covered either with inscriptions or with bas-reliefs. From thirty to sixty laborers were constantly employed for more than six months in the manual labor of excavation alone; and this will show, perhaps better than any statement of measures or other statistics, the actual extent of, and the expense attending, these researches. The number of rooms whose outlines were in a tolerably good state of preservation was fifteen, but there were traces of others, as we shall hereafter mention. As the mound increased in heighth toward the centre, the upper part of the stones became more and more perfect, until they were found of their original size, and farther, the tops of these were in some places nearly or quite ten feet below the surface of the mound, making the whole depth of the excavations in such places about twenty feet. In a few instances, however, these stone slabs were sixteen feet high, being made thus large to accommodate the gigantic figures upon their surface.

Although the writer feels that it is quite impossible by description to convey an accurate idea of the sculptures found on these stones, yet, in the absence of drawings, he will use his best endeavors to supply their place.* The largest bas-reliefs are of human form, about sixteen feet high. Between the left sides and suspended arms of these, lions are held dangling in the air, while serpents are grasped by the right hand, which hangs extended a little forwards. These figures are but few in number. The monsters by the doorway, already described, are the next in size, and others like them are found in several other similar situations. The surface of the whole remaining line of wall, is to a great extent covered with human figures nine feet high. These represent kings, priests, manacled captives, soldiers armed with bows and quivers of arrows, and servants, some of whom are bearing presents to a king, while others have upon their shoulders a throne or chair of state. Where the figures are not of this large size, they are found in two rows, one above the other, and between the rows are inscriptions, generally about twenty inches broad, each inch representing a line of the writing. But we will leave the inscriptions for the present. The figures above and below them, are grouped together, as if to represent historical events. Some ten or more cities or castles are found represented in different rooms, and remote from each other, all undergoing the process of being beseiged, and the enemy without, in every case, triumphant.

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* Mons. Botta, in addition to many other favors, which the writer takes this opportunity to acknowledge, has been so kind as to furnish him with an accurate plan of these ruins, but as the insertion of it here would anticipate the volumes to be issued by the French government, it is deemed but a just regard to his generosity to withhold its publication.

Upon the walls of these castles are men in a great variety of attitudes, some with both hands uplifted, as if imploring for mercy, some engaged in defence, some transfixed with arrows and falling forwards, and some already surrounded by flames, while before them men are sometimes impaled, their countenances distorted as if in the agonies of death. The besiegers are not only triumphant, but are represented as larger than the besieged in stature and more noble in mien. They also appear in many different forms: while some are shooting arrows at those on the walls, and some with torches are setting on fire the gates, others still are protecting these from the weapons of the besieged, by holding before them round or rectangular shields. In fine, it seems to have been the artist's design to represent in, upon, and around the castles, every attitude that warriors might be supposed to take in such circumstances. Upon the front of each of these structures a short inscription is found. These are different one from the other, and probably designed to communicate the name by which it was known. As the castles themselves are only three or four feet high, the figures here described are of course small. Of figures about the same size with the castles there is also a great variety. Here a two-wheeled chariot of war is seen containing three persons, one in royal apparel drawing a bow, another by his side protecting him with a shield, and the third one guiding the horses, who are four abreast. There a king is seen riding in a similar chariot in time of peace, with an umbrella held over his head by one, and the horses conducted as before by a second attendant, all being in an erect posture. In one place a feast is represented, the guests sitting on opposite sides of tables, and on chairs, in true occidental style, while servants are bringing fluid in goblets, which other servants are employed in filling from immense vases; the vases, goblets, chairs and tables all being highly ornamented with carved work. In another place a navy is represented as landing near a city. A number of boats well manned and loaded with timber, are approaching the shore, while others are unlading timber from other boats, and others still are engaged in building a bridge, or perhaps a sort of carriage-way for the mounting of battering-rams. In the water are seen crabs, fish, turtles, *mermaids*, and a singular monster shaped like an ox, with a human head and eagles' wings. One room, thirty feet square, has its walls completely covered with a hunting scene. Trees, having the shape of poplars are the most prominent objects. The branches of these abound with birds, and the space which separates them one from another, with wild animals. In this forest or park the king and his attendants are sporting; a bird is transfixed with an arrow while on the wing, and a servant is carrying a fox or hare, the evidence of previous success.

But this is perhaps enough to give—all that is attempted—a general idea of the scenes represented. The character of the sculpture is in some respects interesting. Some figures but a few inches in length, are so perfect as to have the toe and finger nails plainly distinguishable. Strong passions are sometimes delineated on the faces, the dying appear in agony, and the dead seem stiff and quite unlike the living, who look as if in actual motion. In general the perspective is indifferent, that of groups bad, and that of the water scene above described,—to mention one case,—is decidedly out of all reason. The costume of all the figures is much like that now worn in the East, the kings having a flowing tunic richly figured, and subjects a simple plain frock, hanging in plaits. The Persian cap, almost exactly as it is seen at the present day, is worn by some; rings are quite commonly suspended from the ears, and round bars, apparently of iron, and made into helixes having two or three revolutions, are worn around the arm above the elbow, while the hair and beards of all are curled and frizzled in as nice a manner as it can be done in any of the courts of modern Europe.*

Portions of some of the figures are painted red, blue, green, and black; the same is true of the trappings of some of the horses, and generally wherever fire is represented it is made more distinct by coloring the flame; but with these few exceptions, hardly worth mentioning except on account of their rarity, all the bas-reliefs now described are of the natural color of the stone from which they project.

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* Near the mouth of Nahr el Kelb or Dog River, a stream which empties into the bay north of Beyroot, on a large perpendicular and artificially smoothed surface of a rock are found figures dressed in similar costumes with some of these. Drawings of the two placed side by side, present so many resemblances that one can hardly doubt but that the artists who made the originals, aimed to depict men of the same age and nation. This striking coincidence, and the fact that the inscriptions at Nahr el Kelb are in the same character with those of the ruins at Khorsabad, seems to give some light as to the probable events which both commemorate.

Heretofore our remarks have referred to bas-reliefs only. We have now to speak of a few complete sculptures, which are more astonishing than any thing yet mentioned. These are immense monsters, having the form of an ox, with the face, hair and beard of a man, and the wings of a bird. Of these there are upwards of twenty, each cut from a single block of massive sulphate of lime. They stand generally in single pairs, at the sides of the main entrances of the building, but at one entrance there are two pairs, and at another three. They differ somewhat from each other in size, but their average will not vary much from four feet broad, fourteen feet long and fifteen feet high. If the reader will apply these dimensions to the walls of some building, he will be much better able to conceive of the magnitude of these gigantic images, than if his imagination is governed by the mere mention of numbers and measures. The shape of these monsters is not uniform, but some of them exactly resemble the figure mentioned above in the scene of boats landing before a besieged city. In these the wings of each side extend above the back of the animal until they nearly or quite come together, but in others they are so carved as not to interfere essentially with the natural shape of the ox. Their breasts and sides are generally covered with small figured work, probably representing a coat of mail, and their horns, instead of protruding, are turned around upon the sides of the head so as to form a sort of wreath. As these sculptures stand in every case with a part of one side contiguous to a wall, the artist left that half of the lower portion of the original block as a basis for the support of the rest. This rendered it impossible for him to exhibit the forwards legs both in front and at the side in a natural position;—accordingly, he made five legs, four visible at the side and two in front, but a person looking upon them obliquely sees the whole number at one view. In a recess of a few inches deep, which exists between the fore and hind legs, are found inscriptions of the same kind as those before referred to.

A few remarks respecting the inscriptions cannot fail to be interesting. The character is that known as the cuneiform or arrow headed, and differs but a little from that found on the bricks of Bagdad. They are in lines about an inch broad and are indented in the stone about a quarter of an inch. Their length, if written in a continuous straight line, would be measured by miles. They read from left to right, like English, and unlike all languages now spoken in the vicinity of these ruins. This fact is determined by the comparison of two passages whose commencements are the same and whose lines are of different length. The number of different characters amounts to some hundreds, and hence it seems unlikely that they represent alphabetic sounds,—perhaps the proper names only are thus represented, while the more common words have each their appropriate sign. In the inscriptions upon the castles or cities, the left hand character of each is generally, and if we mistake not, in every case the same. The extent of the records found in these ruins and their relation to the bas-reliefs is such, that there can be no doubt that they will one be day deciphered, and that thus the history of ancient times will have been transmitted directly down to us without the possibility of any forgery. That their solution will confirm and throw light upon Holy Writ we may also hope; and especially as there was in Scripture times much intercourse between Assyria and the Holy Land. In order to ensure the greatest accuracy in the preservation of these records, Mons. Botta has not only copied them with extreme care, but he has had impressions of them taken on paper, by means of which the originals can at any time be reproduced by a casting of wax or plaster of Paris.

As if to leave nothing undone that would serve to bring these ruins within the reach of the curious, two of the monster oxen which were in a perfect state of preservation, have been cut in five pieces with the view to send them to Paris, where they are destined to guard the main entrance to the Royal (?) Museum. Thirty of the best preserved blocks containing bas-reliefs have also been removed, and will probably not be separated from their guardian cherubim.* These were transported to the Tigris on cannon carriages furnished by the Pasha of Mosul, and from there upon rafts floated by inflated skins, to the mouth of the river, and will be carried eventually around the Cape of Good Hope to their final destination. A small bronze lion, weighing say seventy-five pounds, was the only metallic antiquity found that is worthy of notice. It had a staple in its back which was evidently once connected by a chain with a similar staple fixed in the floor. Besides this the only relics which remain to be noticed are some

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* See Art. *Cherub* in Robinson's Calmet.

images made of clay and baked in a furnace. They were found in cavities under a brick pavement, which exists in the inner part of each entrance. This pavement is composed of two layers, and the cavities were formed by leaving out a single brick from the lower layer. For what use these *hidden* images were intended, can only be a matter of conjecture. Were they tutelary deities, placed there to guard the entrances to this monument of art?

To remove any indistinct and incorrect impressions that may have been received from reading the above account of these ruins, it may be well to present a general view of them in another form. For this purpose, with such light as our observation of their present state affords, we will endeavor to describe the construction and overthrow of this palace, temple, monument of Ninus, or, whatever else it be, this depository of ancient archives. For its base there was erected an oval mound, nearly half a mile in circumference, and twenty feet in heighth above the surrounding plain. Over the level surface of this, a layer of sand, brought from the Tigris, was spread about a foot in thickness. This formed the floor and foundation of the whole building, and was made hard by means of stone rollers, (some of which have been found,) in the same manner as the roofs of buildings are treated throughout the southern part of Turkey in Asia at the present day. Besides the doorways, the floor was no where covered, except in such places as were peculiarly exposed,—for instance, near the walls;—and here are found two layers of kiln-burnt brick, one above and one below the stratum of sand. Upon this foundation thus prepared, the walls of the building were erected. These were of sun-dried brick—from ten to fifteen feet in thickness, and faced every where, next the floor, both within and without, with blocks of sulphate of lime, ten inches thick, ten feet high, and of different breadths, and these were covered on the exposed surface with inscriptions and bas-reliefs. Above these blocks or slabs, the wall was faced with a tier of kiln-dried brick, painted straw-colored on the inside. How high this tier of bricks extended, we have no means of determining. Its top must have been at least sixteen feet above the floor, as a few of the stones lining the wall were of this heighth; and probably it was considerably higher, else the oxen at the doorways must have reached nearly to the ceiling of the room, and accordingly must have been, as to size, altogether out of taste. Upon the walls, and reaching from one to the other, were immense timbers, (a few preserved fragments of which have been found,) more than thirty feet in length; and upon them, to complete the roof, was a layer of earth, probably of considerable thickness. Thus, it will be seen, a building was constructed worthy of the simplicity of the first ages of the world, and in strange contrast with the sculptures that formed its ornaments.

Without doubt the building was destroyed by fire. Enough charcoal exists among the ruins to justify this supposition, and also the one that wood was employed about the doors and roof. Further, the calcination of a portion of some of the stones, and especially of their exposed surfaces, shows this to have been the fact. If, now, there were several feet of earth upon the roof, and if after the falling of this, portions of that part of the wall lined only with brick tumbled inward, it can easily be seen that the rooms were soon filled up with rubbish so high as to bury the stones that faced the lower part of the wall. In some parts of the building these stones may not have been completely buried, and hence succeeding generations may have found and removed these portions, without being aware of, or without caring to remove, those which remain. If this has been the case, it will explain the fact that the outlines of other rooms than those enumerated in our description can be traced, although the stones which lined their walls are not to be found. That such stones once existed, is inferred from the analogy of the rooms which are more perfectly preserved, and from the fact that the doorways of these rooms, like the other main passage ways, are guarded by the monster oxen before described—which were probably so large as to be immovable by any power that the pilferer of the works of his predecessors could command.

Before closing this account, it will be but a just tribute of merit to say a few words respecting the gentlemen who have been engaged in developing the ruins now described. Mons. Botta, the discoverer, is son of —— Botta, author of the History of the American Revolution. He has been for many years a traveller in foreign countries, is acquainted with various languages, and is by nature a man of taste and accurate discrimination. With all these qualifications, however, had he not made the investigation of antiquities a study, and had he not, by experience in Egypt, become aware of the value of accurate details in publications relating to this, his favorite science, he must often have failed to record facts, the importance of which none but those learned in this branch of knowledge are prepared to appreciate.

The work of making the plans and drawing the sculptures and bas-reliefs, was committed to Mons. Flandin, a French artist. This gentleman, besides being master of his profession, brought to this field extensive experience, acquired in similar labors among the ruins of Persepolis. His aim in performing the part assigned him, has been to represent with distinctness and accuracy, the size and character of the mound, the ground plan and elevation of the walls, and the present state of all the bas-reliefs and sculptures, leaving injured portions and imperfections in the ruins to appear in the drawings, and to be restored and improved or not, as may suit the taste and imagination of those who may examine his records.

We understand that it is proposed to publish the inscriptions and drawings in four folio volumes, each volume to contain about a hundred plates—half being inscriptions and half plans and draughts. It is sufficient assurance of the character of this forthcoming work, to say that it is in the hands of the French government, and that it will be performed in the best style of the best artists of France.

In conclusion, the writer would beg not to be considered accountable for any thing more than the general accuracy of the foregoing statements. The fact that he writes six months after visiting the ruins, while several hundred miles distant from them, and at intervals of time crowded with other important duties, is his apology for this remark.

Broosa, Asia Minor, April 5, 1845.

Art. XIII.—*On several New Plants;* by Dr. M. C. Leavenworth,—in a letter to the Junior Editor.

The description of the following singular plant (forming a new genus) appeared first in an article by Dr. John Torrey, in the Annals of the Lyceum of Natural History of New York, Vol. IV, p. 76, 1835—"An account of several New Genera and Species of North American Plants." It has not yet been described in any American work on botany, and its republication it is hoped will not be unacceptable in this place.

AMPHIANTHUS.

Calyx 5-parted, and unequal. Corolla tubular-infundibuliform; limb somewhat bilabiate, 4-lobed; inferior lobe somewhat larger. Stamens 2, superior, included; inferior ones wanting. Style simple; stigma minutely bifid. Capsule obcordate, compressed, 2-valved, opening at the summit; valves entire. Seeds numerous, naked, anatropous. Herbaceous, minute, annual, throwing up filiform scapes; radical leaves linear, sessile; flowers solitary, both radical, and at the summit of the scapes.—*Nat. Ord.* SCROPHULARINEÆ.

AMPHIANTHUS PUSILLUS.

Root annual; fibrous, the fibres compressed, linear. Stem very short, compressed, bearing a tuft of oblong linear *leaves* at its summit. Leaves about 2 lines long, rather obtuse, entire, veinless, somewhat succulent. Scapes filiform and very slender, and 1 to 1½ inches in length, compressed, bearing a single pair of opposite oval bracts at the top. Bracts nearly sessile, obtuse, somewhat succulent, obscurely 3-nerved. Flowers very minute; radical ones 2 to 3 on each plant, attached to short recurved peduncles, which originate from the tuft of leaves; terminal ones solitary, nearly sessile between the bracteæ, (that is, without any proper pedicel.) Calyx 5-parted; the division oblong, erect, very obtuse, dotted with a number of minute glands. Corolla scarcely a line in length, white, straight, tapering downward; limb somewhat dilated, slightly bilabiate, 4-lobed; the lobes erect, rounded, and somewhat emarginate; the inferior one larger. Stamens constantly 2, superior, scarcely half as long as the corolla; filaments slender, adnate the lower two thirds of their length, smooth; cells of the anthers approximated, subglobose. Ovary ovate, acute, compressed, surrounded at the base with a minute red disk, 2-celled, many-seeded; style rather larger than the ovary, subulate; stigma minute, bifid at the summit. Capsule broadly obcordate, compressed, opening along the edge at the summit; valves entire, convex; dissepiment adhering to the valves. Seeds 10 to 15 in each cell, linear oblong, fuscous, straight; embryo straight; cotyledons oblong, distinct; radicle oblong.

Hab. in small excavations on flat rocks, where the soil is wet during the flowering season; Newton County, Georgia. Flowers in March and April. *Dr. M. C. Leavenworth!*

Obs.—Specimens of this minute plant were sent to me in the autumn of 1836, by the discoverer, and also by Dr. Boykin, of Milledgeville, Georgia, who received them from Dr. Leavenworth. It has hitherto been found only in one spot, where it occupies a space of four or five feet in diameter, to the exclusion of almost all other plants. It resembles, at first sight, a Callitriche; and when overflowed, the slender scapes doubtless become natant. The plant belongs to the order Scrophularineæ, and is nearly allied to Veronica. Its characters and habit are, however, so peculiar, that there can be little doubt of its constituting a new genus. From Veronica it differs in its tubular-infundibuliform, 5-lobed, and somewhat bilabiate corolla. The most remarkable character of the plant is its twofold inflorescence; part of the flowers being produced near the root, on short naked pedicels which originate among the radical leaves, while others are supported on long capillary bibracteate scapes. The flowers in both situations are perfect; not like those of Amphicarpæa, some species of Polygala, and many Violæ, of which those produced near the root are incomplete. In *Milium amphicarpon*, Pursh, (of which Kunth has made a distinct genus,) the subterranean flowers, as in the Amphianthus, are perfect, like those of the panicle.

In describing the seeds, I have used the term anatropous in the sense in which it is employed by Mirbel, and as explained by Dr. Gray in his excellent Elements of Botany.

Stillingia oblongifolia, *mihi.*

A new species, Linnæan class Monœcia, natural order Euphorbeæ. Fruticose, (shrubby,) stem erect, 3 to 4 feet in height previous to branching, smooth, $\frac{3}{4}$ of an inch in thickness; branches terminating the shrub (terminal) 4 to 6, 6 inches in length, sparingly subdivided; leaves entire, somewhat coriaceous, glabrous and shining above, paler beneath, 3 to 4 inches in length, oblong, obtuse, slightly narrowed at base, an inch in width; petiole about 2 lines in length; leaves mostly at the extremity of the branches; spikes of flowers terminating the branches. Flowering in May. Found in flat, grassy, and somewhat wet situations in the piny woods one and a half miles west of Fort Frank

Brook. This stockade work was on the Stenahatchie, six miles from its mouth.

STILLINGIA LIGUSTRINA, *Michaux.*

A bushy and much branched shrub, 3 to 6 feet in height; leaves thin, entire, lanceolate, and tapering at each end. I do not think it has been observed by others than myself westward of Georgia. Found by me in eastern Texas, near the residence of Dr. Veatch, about forty miles west of the Sabine River.

ULMUS CRASSIFOLIA, *Nuttall.*

This tree has not yet found its way into any general work upon American plants. Described by Mr. Nuttall in the Transactions of the American Philosophical Society, Philadelphia. Leaves crowded, scarce an inch in length, 5 lines in width; oblong, ovate, obtuse, serrate, somewhat pubescent beneath, scabrous, unequal base, thick. Flowering in July. I notice this tree, because Mr. Nuttall did not find it in flower, and was therefore unable to complete the description. Found on the Red River prairies in the vicinity of Fort Towson; from thence westward to the Cross Timbers, about thirty five miles beyond the mouth of the False Washita, the last large tributary of the Red River from the north. The Cross Timbers are said by the hunters to be a line of timbers extending from the Red River to the Missouri. I have also seen it in Texas skirting a small prairie two miles from the Sabine, near the road from Natchitoches, La., to Nagadoches, Texas.

The usual and proper time of flowering is undoubtedly in July. I however found it in flower in Texas in September. It is a tree of middle size, and affording an abundance of shade. Trunk 1 to 1½ feet in diameter; commences branching 6 or 8 feet from the ground; branches very intricate and thick. In the Red River prairies it is generally found on the summits of swells or elevations, in clumps of from four to ten, giving an agreeable variety to the otherwise monotonous prairie. It would be useful and ornamental as a shade tree. In other American species of Ulmus the inflorescence appears early in the spring, (in the southern states in February,) and precedes the foliage. In this the foliage appears the last of April or the first of May, and the flowers in July.

Sophora affinis.

For description, see Torrey and Gray's Flora of North America, natural order Leguminosa. Found by myself and Mr. Beyrich in the Red River prairies, and by Mr. Drummond in Texas near the same time. A shrub or small tree 20 to 25 feet in height, allied to the *Sophora japonica*, but quite distinct. Legumes singular in appearance, consisting of 4 or 5 globose nodes, with linear contractions separating them; flowers numerous, pale purple, large, and quite showy; as showy as any of the species of locust, (Robinia.) It would be extremely desirable to cultivate for ornament. Abundant on a rocky ridge about one mile from Fort Towson, near the road leading to the landing on Red River.

Sapindus.

This interesting and very rare tree, hitherto found only on the coast of Georgia, frequently occurs on rocky eminences near Fort Towson. A small tree varying in height from 15 to 35 feet.

Sanguinaria Canadensis.

This common plant I notice merely to record the extent of its range. It is found at Fort Towson, on the rocky bluff near Gale's Creek. I have never met with it in Louisiana.

Mammillaria vivipara?

Found on the Red River prairies frequently. Natural order Cactacea.

Philadelphus hirsutus, *Nuttall.*

Natural order Philadelphiæ. Abundant on the bluff at Fort Towson, near Gates' Creek. A highly ornamental shrub 2 to 4 feet high; flowers very abundant and extremely fragrant. Found by Nuttall near the French Broad, Tennessee.

Nemostyles cœlestina, (*Ixia cœlestina*, Bartram.)

First noticed by Bartram, but lost sight of until lately. Found by Nuttall between the sources of the Pottoe of Arkansas and the Kiameshe, a tributary of Red River. By myself on the point of land at the junction of the Red and False Washita rivers. Frequent in western Louisiana, near the Sabine River; still more frequent on the Texas side of that river; occasionally also in the vicinity of Fort Jessup, La. Inner petals are cucullated or cowled in a very peculiar manner. The centre of the flower is yellowish and maculate; the laminæ of the petals blue.

NEMOSTYLES GEMMIFLORA, *Nuttall*, in Trans. Philad. Phil. Soc.

Flowers a beautiful blue an inch or more in diameter. Found by myself in the vicinity of Fort Towson, western Louisiana, eastern Texas, and the prairies of Alabama near Demopolis, as long since as the year 1821. Both species are beautiful plants, belonging to the natural order Iridæ.

You will perceive my object in the details of this communication. It is—

1st. The description of new and unknown plants.

2d. Additional memoranda relating to those that are rare and little known.

3d. To enlarge the knowledge of the range of certain plants.

Waterbury, Ct., May 5, 1845.

ART. XIV.—*New Electro-Magnetic Engine;* by CHAS. G. PAGE, M. D., Professor of Chemistry and Pharmacy, Columbian College, Washington, D. C.

THIS new species of electromotion, which by way of distinction I denominate the axial reciprocating engine, was unsuccessfully attempted in the year 1838, and notice made of it in this Journal, Vol. xxxv, for 1839, pp. 261 and 262, together with some other experiments upon the interior of helices. My failure at that time was owing to a want of suitable batteries, but being furnished in the winter of 1843–4, with some of the excellent batteries of Prof. Grove, I recommenced the experiment, and exhibited one of these interesting engines to the members of the Geological Association held in this place in May, 1844. To sustain a small needle within the helix is a trite experiment, but by the arrangements I have adopted, a bar of soft iron or of steel (which becomes instantly and powerfully magnetized) is sustained entirely free from any visible support, and this too by the action of only six small Grove's batteries. This is almost a realization of the fable of Mahomet's coffin, or the statue of Theamides. When the helix is connected with six pairs Grove's, in good action, it will draw up within its centre a bar of iron or steel weighing two or three pounds, and sustain it with its upper end projecting above the helix. When the bar is very light, for instance a tube of sheet iron, and somewhat longer than the helix, its upper end will project nearly as much above, as its lower end is below the helix. A variety of very pleasing experiments may be made with things thus arranged. If the battery circuit be broken rapidly, the bar will not drop, but exhibit a rapid vibratory or dancing movement. If the battery current be slightly diminished without actual interruption, and there are various well known ways of doing this, the bar will sink, and rise again on restoring the full power of the circuit. The sensation is novel and peculiar when the bar is pulled down slowly through the helix, owing to the great space—at least three inches—through which the action is sensibly maintained. If a string be attached to the bar and the circuit broken by drawing the wire across a rasp or file, to a person holding the string, the sensation is precisely that felt by the angler when the fish has seized his hook. As pleasing modifications of this experiment, I have contrived several instruments, one of which is called the *watchman in his tower*.* The helix is mounted upon a stand, and the connexions with its extremities so arranged, that when the connecting wires with the battery are made to touch the legs of the stand, the armature or bar which is concealed within the helix, instantly starts up and exhibits the figure of a man upon its upper end, which falls back upon breaking the circuit.

Another curious instrument is the galvanic or magnetic gun. Four or more helices arranged successively, constitute the barrel of the gun, which is mounted with a stock and breech. The bar slides freely through the helices, and by means of a wire attached to the end towards the breech of the gun, it makes and breaks the connexion with the several helices in succession, and acquires such velocity from the action of the four helices, as to be projected to the distance of forty or fifty feet. Among the useful results of this principle of action, are a galvanometer of great value to the experimenter, and the electro-magnetic engine. The galvanometer gives an actual measurement by weight of any combination of pairs, up to that number which is beyond the saturating power of the bar or magnet within the helix, that is to say, for an instrument with a given sized

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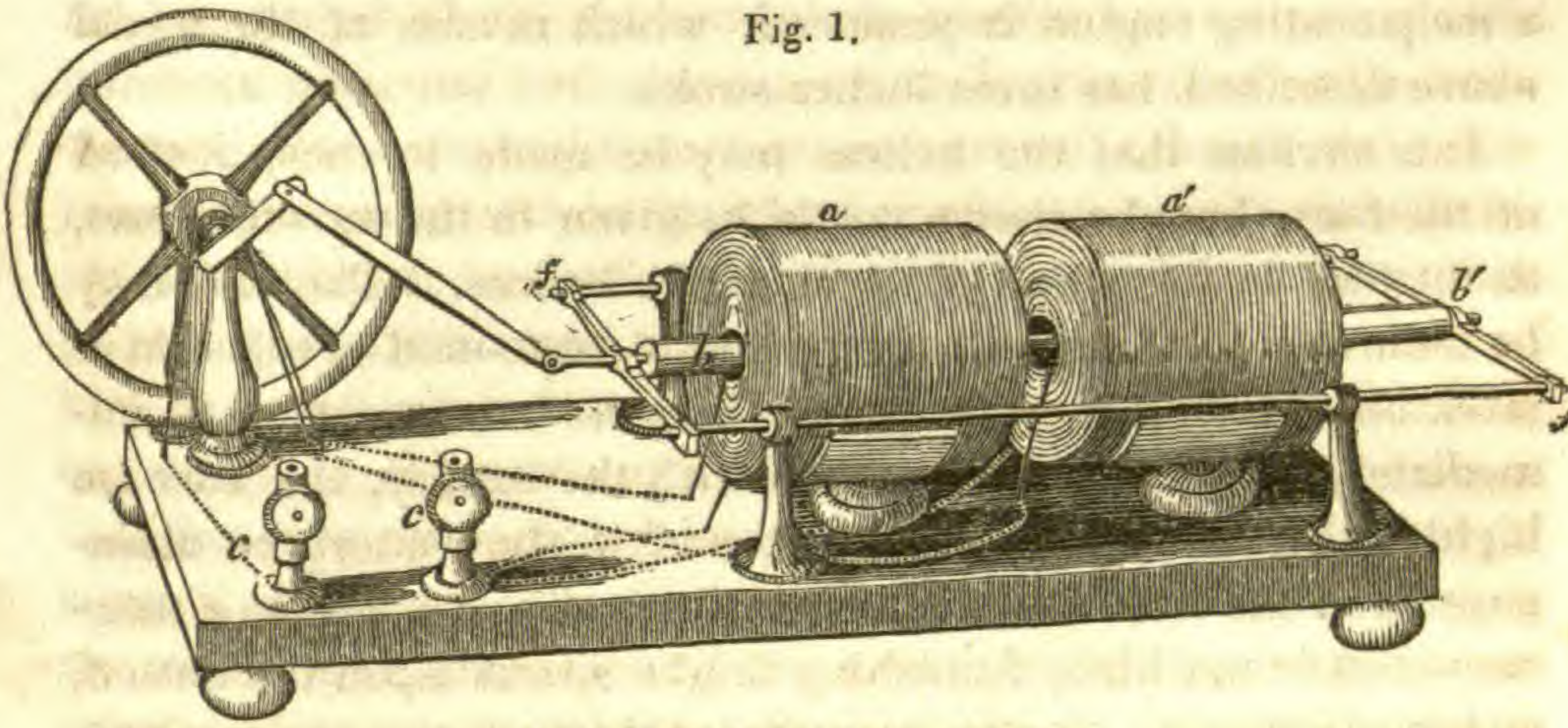
* This instrument and the magnetic gun will be particularly described in the next number.

helix; for the size of the helix and bar may be increased so as to measure the power of any number of combinations. The bar in this case has its lower end just within the upper part of the helix, and its upper end attached to the hook of the spring balances commonly used in shops and elsewhere, for weighing light goods, &c. The great power of the helix in this case is due to the proportions of its length and diameter, and the length of the wire to the quantity and intensity of the current. The helix is about four inches long, three inches diameter, central opening three fourths of an inch diameter, and of one continuous copper wire, of size No. 16.

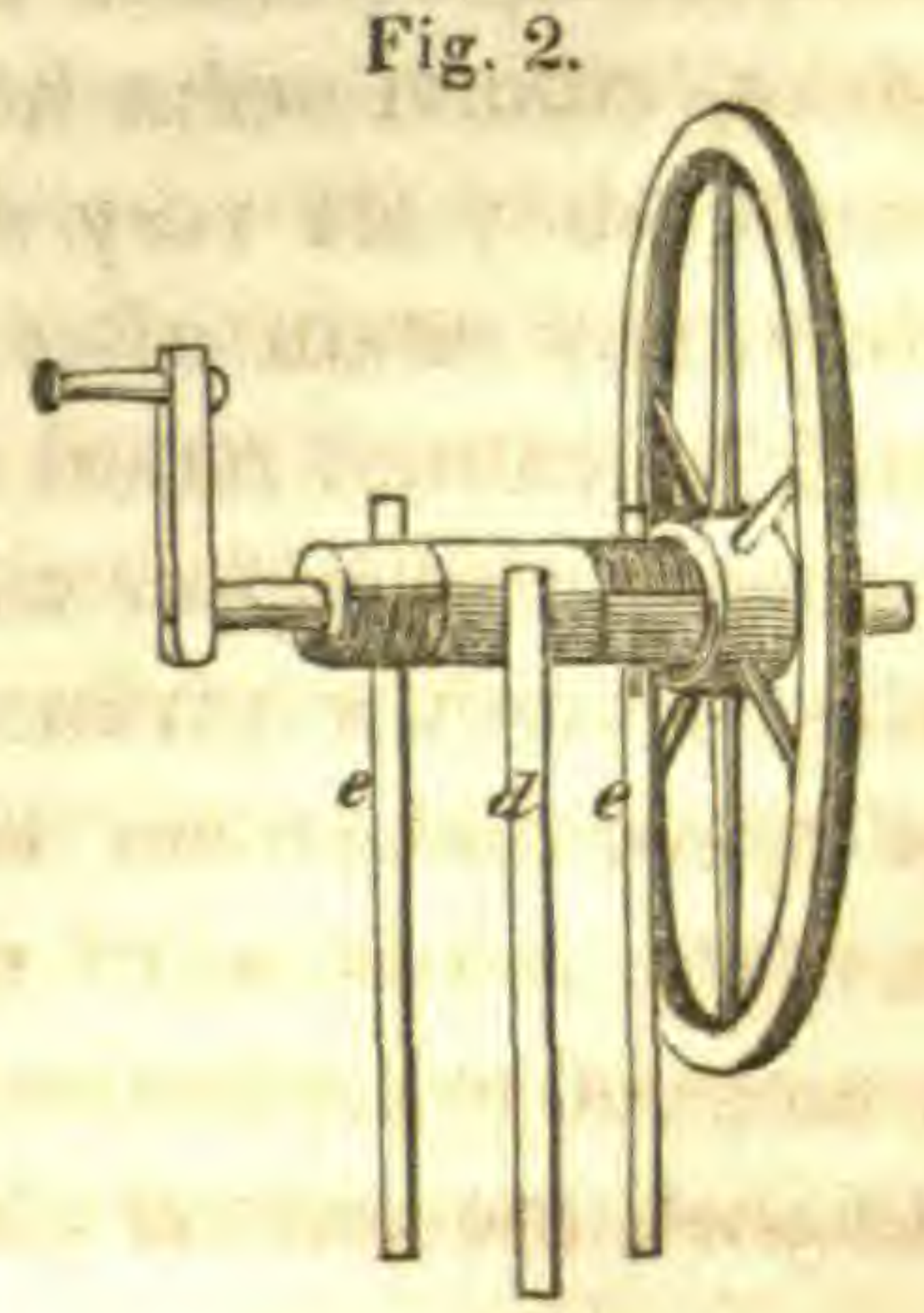
Fig. 1.



AXIAL RECIPROCATING ENGINE.

The construction of the engine will be readily understood from inspection of fig. 1. *a*, *a′* are two helices of the above description, firmly secured to the base board, and set with their axes exactly in a straight line. The two bars, *b*, *b′*, connected together by a stout brass rod, are attached to a sliding frame, *f*, *f*, and made to play with as little friction as possible. The wires from the extremities of the helices pass down through the base board, and the proper connexions are made with the cut-off upon the shaft of the fly-wheel, as shown in the detached figure 2. The dotted lines indicate the course of the wires and their connexions with the cups, *c*, *c*, and the conducting springs, *e*, *e*, fig. 2. The operation of the cut-off or electrotome, will be readily understood by any one familiar with the rotary machines without change of poles, which I published several

Fig. 2.



years ago in this Journal, where the same device was used for the purpose of intercepting the galvanic current from one helix or magnet, and throwing it upon a second, then a third, and so on in succession. The bar *b*, as represented in the figure, has nearly reached its position of equilibrium with the helix *a*, and by its motion through the helix, has carried the bar *b'*, which is attached to the same frame, into a position to be acted upon by the helix *a'*. When *b* is at its position of equilibrium, the crank of the fly-wheel is at one of its dead points, the cut-off on the shaft intercepts the galvanic current from *a*, and conducts it into *a'*, which then draws in the bar *b'*, and thus a reciprocating engine is produced, which in case of the model above described, has three inches stroke.

It is obvious that the helices may be made to move instead of the bars, but the choice would be given to the movable bars, as they are in this case lighter than the helices. The bars may be hollow or solid—solid bars answering best—and of soft iron or steel, but soft iron is preferred. When the bars are of steel, immediately after using the machine with the battery, the bars are highly charged with magnetism, and if the battery be disengaged and the machine worked mechanically, it becomes a magneto-electric machine, furnishing bright sparks upon the cut-off, and strong shocks. In this experiment the two cups, *c c*, are connected by a short wire. In operating this machine by the battery, it exhibits one of the most beautiful, simple, and at the same time most powerful movements ever produced by electro-magnetism. The peculiar advantages of the arrangement are as follows: *First*, a continuous action may be maintained through a very great distance, as will be by-and-by explained. *Second*, the retardation common to all other forms of electro-magnetic engines, cannot occur here; for as the bars to be magnetized are small, they are very rapidly charged, and whatever magnetism they may retain after the galvanic current is intercepted in the helices, cannot retard their motion, as there can be no attraction between the copper wire of the helices and the inclosed iron bar. Hence with a given quantity of battery surface the maximum of speed and power is obtained. The retardation from the permanent retention of magnetism, the time occupied in charging a magnet to saturation, and the time required to discharge the magnet, are serious obstacles in the way of obtaining any available power in ordinary electro-magnetic machines, and occasion that singular anomaly,—that the actual power of such machines diminishes as their rate of revolution increases. Add to these difficulties, the influence of secondary currents, which, as I have shown several years since,* always remagnetizes a bar of iron after the battery current is cut off, and the *third* advantage of the new engine will be appreciated,—for in the first place, the secondary current occurs in all other forms of electro-magnetic machines, when the armatures or magnets are very near the point of greatest action, but in this engine the secondary current occurs at the farthest possible distance from this point; and in the second place, the secondary current has no perceptible influence upon the inclosed bar when it *does* occur. The mechanical power derived from this arrangement, should it ever be found economical, will be increased, by increasing the number of small machines. Any length of stroke may be obtained by arranging the helices in a straight line and causing the bar or bars to pass through the whole length, multiplying the number of helices, in proportion to the length of stroke.

It has long been a mooted question among mechanics, whether a rotary steam engine would have any real advantages over the reciprocating engine, and as no genius has arisen to give us a rotary engine which might claim comparison, it is *still* a question. But in regard to *this kind of electro-magnetic engine*, the rotary form is most desirable, for certain reasons to be hereafter explained. This interesting modification of the experiment, was matured some few days after the reciprocating engine was completed, and will be shortly explained. In addition to the power of the helix in drawing the bar within itself, I have availed myself of an extra source of attraction, viz. the actual power of the magnet, which receives an additional impulse by the attraction between it and an armature or bar of soft iron. This impulse, which is powerful, is received at an unfavorable moment, as it is nearly at the end of the stroke, when the crank is only a short distance from the dead point; but I have made use of it nevertheless to advantage, by an arrangement which I will describe in the next number. In the rotary form there is no mechanical difficulty of this nature to overcome.

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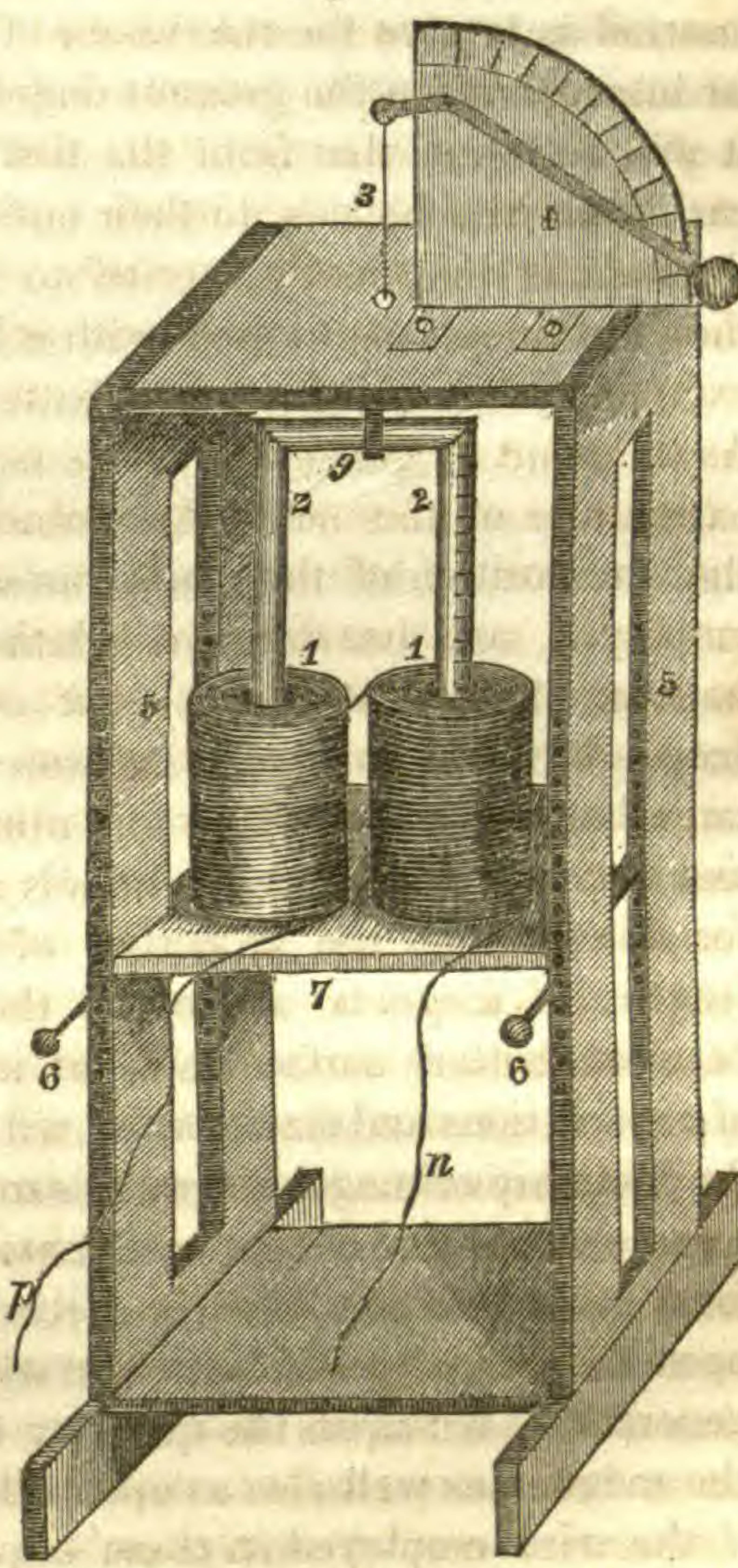
* This Journal, 1838, Vol. xxxiv, p. 372.

ART. XV.—*Axial Galvanometer, and Double Axial Reciprocating Engine;* by CHARLES G. PAGE, Prof. Chem. and Pharm. Columbian College, Washington, D. C.

The Axial Galvanometer.—As this instrument possesses characteristics distinguishing it from all others, I have selected for it the term *axial*, as appropriate and in some measure descriptive of its character. In all the known forms of galvanometer, the magnetic needle or a bar of magnetized steel is used, to indicate the action of the galvanic current, or else the coil of wire itself is free to move, while the needle or bar is stationary. In all such instruments there is one liability to error from a source not sufficiently regarded, viz. the frequent disturbance of the power of the needle by the magnetizing power of the current in the coil, which, if the needle is in such position as would naturally result from the action of the coil, will slowly increase its magnetic power, and if forced by accident or otherwise into a reverse position, will diminish its power, and ultimately reverse its polarity, provided the current be powerful and the action continued for any length of time. In the new instrument, no permanent magnet is used, the motion necessary for purposes of indication being made by the action of the coils upon a bar of soft iron. Every bar of soft iron retains, after being powerfully magnetized, a certain amount of magnetic power; but this, if the bar is not very large and hard, is very small, and may be considered as nearly a constant quantity. I have sometimes thought that the term absolute galvanometer might well be applied to this instrument, as it immediately indicates by weight the absolute force exerted upon the iron bar. I would not recommend the mounting of the instrument in the style exhibited in the figure, as the sketch is taken from the instrument in its primitive form. Many modifications will suggest themselves of modes of constructing the instrument, as well as the means of indicating the forces.

The U form bar 2, 2, Fig. 1, is of soft iron carefully annealed, well polished, and graduated to spaces of one sixth of an inch upon one of its legs; the diameter of the iron is about one eighth of an inch less than the opening in the centre of the helix, to allow free play as the helices are raised and lowered, or the magnets drawn down within them. The bar is suspended by a small brass wire 3, passing through the top board of the framework, and attached to the short arm of a bent lever balance, 4. The helices are supported upon the shelf 7, which is raised and lowered, and sustained by means of the pins 6, 6 passing through holes in the frame and under a projection from the shelf, which slides freely in the slot 5, 5.

Fig. 1.



The wires from the helices *p*, *n*, are to be connected in any suitable manner with the poles of a battery. Guide-rods or pins may be inserted in the poles of the magnet, which pins or rods may pass through holes in the centre of a plate of metal let into the lower board of the stand, or one a little more raised, so as to allow for the motion of the entire length of the bar; but this last device is hardly necessary, for if the bar should incur friction by touching the helices, it is easily freed from it by slightly shaking the apparatus. I have sometimes used the spring balance instead of the bent lever, and although the former is not so sensitive as the latter, yet it possesses some advantages. In the bent lever balance, the point of suspension of the wire 3 must describe an arc of a circle, while in the spring balance the point of suspension moves in a straight line, making less liability to friction.

Operation.—When an intensity battery, say two or any number of Grove's battery, is connected with the helices by means of the extremities *p*, *n*, the bar 2, 2 is drawn down with a degree of force which will be indicated by the scale of the balance. The force indicated will vary with the degree of insertion of the bar. When its legs are just within the helices, the action is slight; as they descend further, the action increases, until they reach a point about two thirds the way down the helices, when the action is at its maximum. By raising and lowering the shelf 7, the action may be varied accordingly, and when the bar is so far inserted as to give the maximum of effect, it should be left thus far inserted when the greatest degree of sensitiveness is required. It will be found that from the first insertion of the legs of the bar within the helices, to their entire insertion up to the bend 9, the force is continually exerted to draw down the bar; and in the experiments performed with a bar 10 inches long, the force exerted by five pairs Grove's battery was equal to two pounds. As the point of greatest action is neither in the centre, nor at the extremities of the helix, but somewhere between them, I find that the position of this point varies with the length of the bars employed, and has different relations in differently proportioned helices. This instrument is not offered as a sensitive galvanoscope, but is calculated to measure the force of currents when large batteries are used, or any number of small batteries joined as a compound battery. It affords at once a valuable instrument for determining the properties of helices of various sizes and lengths, of magnets, and of all those relations and proportions between battery surface, size of iron for magnets, and number of convolutions and size of wire, which must be determined before the economy of magnetic power can be settled. It would require a vast expenditure of time and material to settle the above points, for it is obvious that the magnetism of the bar does not depend upon the quantity of electricity which the battery is capable of generating, but upon the quantity circulating in the wire around the magnet, as well also as upon other conditions. For instance, if the wire employed in these experiments be wound after the method of Prof. Henry in separate strands, the five pairs Grove's will manifest but very little action upon the magnet or inclosed bar. And if the same wire is one continuous piece, as it is actually used, and the same surface exposed in the five pairs be converted into one pair, the action will then also be very slight.* This is one of the most important principles to be regarded in all

* The calculations made, and advanced by several European philosophers, upon the amount of zinc consumed, cannot in view of the above, be regarded as affording a test of the inapplicability of electro-magnetism as a mechanical agent.

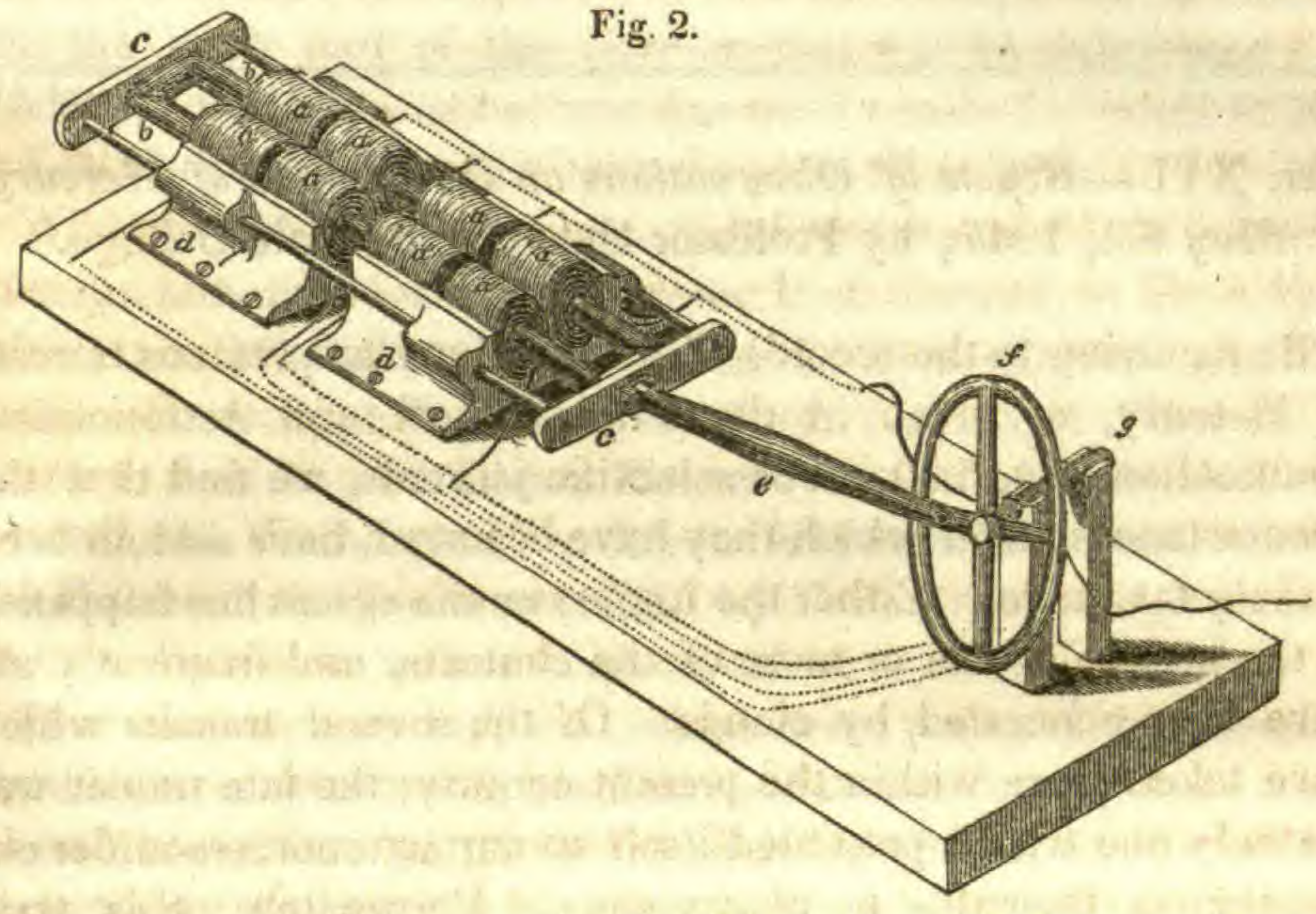
of the applications of galvanism for the development of magnetism. The proportions of battery, and length and size of wire, and relations of length to diameter of the helices used in the instrument just described seem to be very near correct, and I am indebted for them to Mr. Vail, Prof. Morse's assistant. I had never seen so great a weight sustained within the helix as in one of about the size used above, and first kindly shown and loaned to me by Mr. Vail. The bar he sustained within a single helix by means of 10 pairs Grove's battery, weighed over half a pound. By modifying the proportions, I have succeeded in sustaining over three pounds, and believe that even ten times that amount may be sustained free of visible support, by proper attention to the several ratios required.

Double Axial Reciprocating Engine.

Before entering upon the description of this improvement, I may be allowed a few remarks as to the nature and design of these publications. Conceiving that this, and the first machine described, and also the several instruments which I have designed upon the same principle of action, form an entirely new era in the science of electromotion, (if we except the delicate experiment of De la Rive's ring, and others of the class of electro-dynamics,) I have thought that the invention would ultimately, and perchance very soon, become one of practical value, and am therefore desirous of securing by patent the right to the following modifications, viz. the single axial engine, the double axial engine, and the rotary form of engine, dependent upon the same species of action; which last will be hereafter described. The galvanometer, being an instrument calculated to be productive of great good to science, without any further modification, the galvanic or magnetic gun, the watchman in his tower, and some other interesting contributions to the *physique amusante* hereafter to be mentioned, I give to the public as instruments of philosophical research and amusement. Situated as I am, being one of the examiners in the Patent Office, it becomes necessary for me to take an unusual step, to secure my title to this novel invention. By the statute law, no officer in the Patent Office can take out a patent for any invention, nor acquire any interest in a patent after his appointment to office. Consequently, if one so situated should make an important invention, he can have no security as long as his invention is known to any second person. As publicity without abandonment is the strongest possible testimony in favor of an inventor, I have resorted, with your indulgence, to the pages of this Journal, to establish the date and nature of my invention, and to give due caution to all as to its use in any way to engender liability. Although I cannot, without resigning my office, enjoy the usual rights of inventors, yet I have every reason to believe that Congress will, by special act, authorize me to receive and hold a patent for this and some other kindred inventions.

The use and action of the galvanometer will readily explain the basis of the double engine. The power of the helices is much better displayed when the U form bar is used instead of a straight bar of iron, as in the first engine. As the straight bar reaches its equilibrium with the helix, when its projecting portions are of equal length, or rather when the centre of the helix exactly coincides with the centre of the bar, it was plainly inferrible, that the U form bar would be drawn through the helices until they were both intercepted by the bend of the bar. This was fully verified by experiment, as follows. A bar of iron of this form, having its legs ten inches in length, was mounted upon a sliding frame—part of its weight counterpoised, and its legs inserted into two helices of three inches length ; the helices were then connected with the battery, and the bar was drawn through the helices until they rested upon its bend. Thus with a single pair of helices and a single bar of iron, a continuous impulse was given through the space of ten inches, affording at once the elements for the most simple and efficient exhibition of magnetic power as a propelling agent. The power, as measured by the axial galvanometer, averaged in this experiment 1¾ pounds through the ten inches; in the last half inch, or that near the bend, the power was two ounces, and at the point of greatest action it was 3½ pounds. I find, moreover, that the helices, if properly suspended, will pass over the entire length of two feet; though, from the difficulty of magnetic induction through such long bars, the power is feeble through a considerable portion of the space. The machine represented by fig. 2, has six inches stroke, and although its mechanical power has not been absolutely tested, yet, for the elements employed, it is by far the most powerful engine of the kind I have seen; and its operation is so encouraging that I am preparing for another engine, of one foot stroke. Upon inspecting the figure, the whole arrangement, which is very simple, will be understood at a glance. The U form bar, *b b*, is joined to one of a similar size and shape, placed at the other end of the sliding frame, *c c*. They are joined by means of brass rods about six inches in length, and of the same thickness as the bars of iron, and both are firmly secured by the cross heads and sliding rods of the frame, *c c*. The helices, *a a*, are firmly cemented in a stout casting, *d d*, which also contains

Fig. 2.



the bearings of the sliding rods. The frame is attached to the fly wheel *f*, by the connecting rod *e*, and crank shaft *g*, after the usual manner. The dotted lines represent the course of the wires from the helices underneath the base board, which again pass up through it, near the crank shaft, to be connected with an electrotome or cut off. This part of the engine will be understood without further explanation by all familiar with the subject. It will be noticed, however, that instead of using a single pair of helices upon the U form bar, there are two pairs. This arrangement makes a great gain of power, for the action upon the bars is made consecutively by the helices while the bars are passing the strongest points of each. In the machine of one foot stroke, there will be four pairs upon each bar, operating consecutively. It is obvious that they may be increased in number as the length of stroke increases, even up to two feet. I have also availed myself of a mode of applying the direct power of the magnet upon a bar of soft iron, in conjunction with the continuous action of the helices; which adds about ten per cent. to the actual power of the machine. The nature of this last improvement will be hereafter explained. The gun, the rotary engine, and some other modifications, will be hereafter described. The above modifications of the engine, the rotary form and the other instruments, were all invented in less than a month's time after the single axial engine, and communicated in confidence to a few friends.

Washington, D. C., June 10, 1845.

Art. XVI.—*Report of Observations on the Transit of Mercury, May 8th*, 1845; by Professor Olmsted, of Yale College.

By recurring to the records of observations on previous transits of Mercury, as given in the Philosophical and Astronomical Transactions, and in various scientific journals, we find that the circumstances under which they have occurred, have seldom been entirely favorable. Either the ingress or the egress has happened in the night; or one or more of the contacts, and frequently all, have been concealed by clouds. Of the several transits which have taken place within the present century, the late transit was the only one which presented itself to our astronomers under circumstances favorable to observation. Fortunately, this transit afforded to a number of accurate observers an unobstructed view of the entire phenomenon, and to others, the opportunity for accurate observations on at least one set of contacts, either those of the beginning or those of the end. Presenting itself to all parts of the United States, as far west as New Orleans, between the hours of ten in the morning and six in the evening, and consequently at a period in the twenty-four hours extremely convenient to the astronomer, it afforded the best opportunities for determining the times of contact, and all the physical peculiarities of the phenomenon. In some parts of the country, on the east, indeed, the morning was threatening and boisterous, so as to prevent good observations on the ingress; and in other parts, on the west, clouds prevented observations on the egress; but so far as we have heard, all observers enjoyed the satisfaction of seeing at least either the ingress or the egress. At New Haven, New York, West Point, Philadelphia, Cincinnati and Charleston, the sky was cloudless throughout; at New Haven the covering of clouds, which had overspread the morning sky, was seen, about an hour previous to the first contact, to be gradually moving from west to east, leaving from the western horizon upwards, a very pure sky. We watched the line of separation with much anxiety as the moment of first contact approached, and had the satisfaction of seeing it clear the sun almost precisely at the desired instant. At Cambridge, Nantucket, and Providence, the ingress was lost in consequence of clouds, but the latter part of the phenomenon was favorably seen; at Hudson, Ohio, the weather was fine until nearly 5 o'clock P. M.; and at Cincinnati, the four contacts were all in view.

We have before us accounts of observations on this interesting phenomenon, made at Providence by Prof. Caswell, at Nantucket by William Mitchell, at New Haven by Prof. Olmsted and Mr. Francis Bradley, at New York by Prof. Loomis, at West Point by Prof. Bartlett and Lieut. Roberts, at Philadelphia by Prof. Kendall, at Washington by Lieut. Maynard and Profs. Coffin and Hubbard, at Charleston, S. C. by Prof. Gibbes, at Cincinnati by Prof. Robinson, and at Hudson, Ohio, by Prof. Nooney.

The observations at Yale College were rendered, by peculiar circumstances which it is needless to mention, less accurate than we had hoped for; so that we could not confide at all in our first contact, nor entirely in our second, or the first internal contact. The want of a suitable observatory for using our ten feet refractor, (Clark's telescope,) prevented the complete success of these two observations with that instrument; but we had good opportunities afterwards of viewing with it the physical appearances of the phenomenon, and of observing the two last contacts. The slowness of the planet's relative motion, being only about an arc of one second in twenty seconds of time, and the want of a distinct indentation upon the sun's limb, like that which marks the commencement of a solar eclipse, conspire to increase the difficulty of being certain of the moment of ingress; while the eagerness of the observer to catch the first glimpse of the real object, whose image is so vividly painted on the mental vision, exposes him to the danger of transferring to the skies what is present merely to the eye of the mind. Prof. Loomis (who, however, unfortunately, had the use of only a small telescope, wholly unsuited to so skillful an observer) remarks, that he was unable to see the ingress, until the planet had advanced one-third of its diameter upon the sun's disk; and he deems it impossible that the first contact could be recognized with entire confidence until at least twenty seconds after it had actually taken place. The Cincinnati observations give the time of first contact within thirty one seconds of the computed time; and those of Hudson, Ohio, differ from the time assigned in the American Almanac, by only about four seconds,—a coincidence which would seem to confirm the computation in a remarkable degree, did not the very exactness imply that the computation was too late, since the ingress could not have been distinctly seen so soon after the moment of contact. The West Point observations give the time of ingress, (marked "uncertain") 1*m.* 28·7*s.* later than the time assigned in the United States Almanac; and the Charleston observations give the time of ingress 2*m.* later than that assigned by the same authority. The time of first contact at Washington, as reported by Lieut Maynard, was 17·1*s.* *earlier* than the computed time, being (when corrected for error of clock) 11*h.* 11*m.* 1·9*s.*, while the time given in the United States Almanac was 11*h.* 11*m.* 19*s.*

If we compare the *intervals* between the first and second contacts, a like or even greater discrepancy will appear.

				m.	*s.*
At New York,	this interval was,			2	38*
At West Point,	"	"	"	3	31·2
At Western Reserve College,	"	"	"	3	34·3
At Cincinnati,	"	"	"	3	33
At Charleston,	"	"	"	3	11

These comparisons show that little reliance can be placed upon the observations made on the first internal contact in a transit of Mercury. Similar discrepancies have also been recorded by accomplished observers abroad. Thus in the observations made at Utrecht of the transit of May 5, 1832, by Dr. Moll and his assistants, the difference between observation and computation varied, as reported by the different obervers at the same place, nearly a minute.† Beside the inherent difficulties arising from the slow relative motion of the planet, and the want of perceptible indentation until it has advanced far on the sun's limb, the magnifying and defining powers of the telescope will also have much influence. This is especially the case with the observations on the internal contacts, where the visibility of the

* The time of actual ingress was not given, but only the time when first seen.
† Ast. Trans. vi, 114.

luminous ring that shows, on the one side, the completion of the ingress, and on the other, the beginning of the egress, will depend not only upon the acuteness of the observer, but also upon the excellence of his instrument. The complete formation of the ring in the first internal contact, and its rupture in the second, furnish the best instants for observation. Professor Loomis determined the moment of the second internal contact by taking the mean of three observations,—first, when a thin ring of light was seen between the limb of the planet and the sun; secondly, when this ring was reduced to a bare line of light; and, thirdly, when there was a decided rupture of the ring. The low magnifying power of his telescope rendered this method expedient, although, had that power been great, the rupture of the ring might perhaps itself have afforded an instant sufficiently definite.

The first internal contact, occurring as it did when the sun was near the meridian, and when the mind of the observer had had opportunity to gain entire composure, was probably the most favorable instant of the whole for an accurate observation. Accordingly, the discrepancies which the observations on this point present are within more moderate limits than those on the first external contact. Reducing to the longitude of New York, (no allowance being made for parallax, which would be a needless refinement in observations differing so much from each other,) they are as follows:

1st Internal Contact.

	h.	m.	s.		h.	m.	s.
New York,	11	27	58·3	Cincinnati,	11	27	49·6
Hudson, (Ohio,)	11	27	15·6	West Point,	11	28	14·9
Charleston,	11	28	36·4				

Least difference, 8·7*s*. Greatest difference, 1*m*. 20·8*s*.

The observations on the second internal contact present the following results:

2nd Internal Contact.

	h.	m.	s.		h.	m.	s.
New York,	5	50	55·7	Nantucket,	5	50	51·4
Cincinnati,	5	50	48·0	West Point,	5	51	9·8
Providence,	5	51	19·8	New Haven,	5	51	21·6
Charleston,	5	51	25·4	Washington,	5	52	46·0

With one or two exceptions, a nearer agreement is seen here than at the second contact; and this would probably have been the best time of all for obtaining an accurate observation, had not the proximity of the sun to the western horizon, produced a tremulous and ill-defined appearance of the sun's limb. In the present case, however, the observations on the last external contact differ least of all from each other. They are as follows:

Last Contact.

	h.	m.	s.		h.	m.	s.
New York,	5	54	29·0	New Haven,	5	54	35·6
West Point,	5	54	36·8	Cincinnati,	5	54	18·6
Charleston,	5	54	40·4	Nantucket,	5	54	16·4
Providence,	5	54	48·8				

Least difference, 1·2*s*. Greatest difference, 32·4*s*.

On comparing the observed with the computed times of egress, we arrive at the following results.

Observed later than the computed time.

	m.	s.		m.	s.
New York, . . .	1	34	Charleston, . . .	1	46
New Haven, . . .	1	53	Nantucket, . . .	1	31
Cincinnati, . . .	1	17	Providence, . . .	2	03

Mean, 1*m*. 42*s*.

This result exhibits as near a coincidence between observation and the calculations given in the American and United States Almanacs, as could have been reasonably expected. At a sitting of the Institute of France so late as the 3d of March last, M. Leverrier exhibited calculations which he had made relatively to this transit, according to the tables of the motions of Mercury, which he had presented to the Academy in 1843. His calculations differ considerably from those given in the Nautical Almanac, the Berlin Ephemeris, and the Connoissance des Temps; and, indeed, these authorities differ materially from each other, as appears by the following comparison.

	1st Contact.			2d Contact.			3d Contact.			4th Contact.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
Nautical Almanac,	4	28	27	———			———			11	00	11
Berlin Ephemeris,	4	28	19	4	38	01	10	56	25	11	08	08
Conn. des Temps,	4	28	40	4	32	15	10	54	58	10	58	33
M. Leverrier,	4	29	55	4	33	36	10	58	59	11	02	41

In the transit of 1782, the French astronomers differed in respect to the ingress through the whole range from 19*s.* to 3*m.* and 9*s.*; and at the third contact they differed from 21*s.* to 1*m.* 44*s.*

If we look back to former periods and see how far observation agreed with calculation, our present results, discordant and imperfect as they are, indicate an encouraging advance in the knowledge of the motions of Mercury, and inspire the hope of soon being able to tabulate them truly. In the transit of 1661, astronomers watched at their telescopes *four days.* Delambre in his System of Astronomy, (t. II, p. 511,) has given us the full particulars of the observations of the French astronomers on the transit of 1786, showing that the best tables of that period are in error nearly three fourths of an hour. "The ingress (says he) occurred at Paris during the night. At sunrise, it was rainy. All the astronomers of Paris were at their telescopes, but tired of waiting they had quit their posts half an hour after the predicted time of egress was past, abandoning all hope. Afterwards the sun came out. M. Messier, who had been making observations on the solar spots, the preceding days, wished to see them again, and thus got a sight of Mercury and observed his egress. I had remained at my telescope for another reason. Having made some researches respecting Mercury, I had seen that for the transit of 1786, the tables of Halley gave the egress an hour and a half later than those of Lalande. I had more confidence in the latter, but it was not demonstrated that Halley was decidedly wrong. I resolved to wait, therefore, till the moment indicated by Halley's tables, but I was not compelled to wait so long, since the phenomenon arrived three fourths of an hour after the time of Lalande, but still three fourths of an hour earlier than that of Halley. Le Monnier, Pingre, Lalande, and his nephew, Mechain, Cassini, and his three adjuncts, deceived by the predicted time, had all missed the observation. I showed them mine that evening, and they would hardly believe it. This was the first observation which I had occasion to repeat to the Academy of Sciences, and it is from that epoch that I date my career as a practical astronomer."

Mercury appeared on the solar disk a round black spot, having an apparent diameter of 11″.6, and of course occupying an extent of only one hundred and sixty fourth part of the sun's diameter. No traces of an atmosphere encircling the planet, could be discerned by an attentive examination for this special object, with our ten feet refractor, with different powers from 55 to 110; nor, so far as we have heard, were any such appearances as were supposed by the earlier observers of the transits of Mercury to indicate an atmosphere, recognized on the present occasion.

In the observations of Dr. Moll on the transit of May 5th, 1832, that astronomer speaks of having seen a grayish spot, on the disk of the planet, and the same appearance was remarked by his assistants;* and he tells us that Schröder and Harding had noted a similar appearance during the transit of 1799. But none of the reports before us speak of seeing any thing on the face of the planet, but all who mention its aspect describe it as uniformly black. Its deep shade of black, indeed, seemed to contrast it very strikingly with several solar spots visible along with it on the sun. Three of these were conspicuous objects in our ten feet telescope, all on the hemisphere of the sun, opposite to that traversed by the planet, and of a pale hue compared with that of the latter.

In the transit of Mercury of May 5th, 1832, M. Schenck, a German observer, thought he saw a satellite accompanying the planet, which he describes as a round black spot as large as the head of a pin,† and distant from the primary about two or three diameters of the latter. It occasionally disappeared, and then came into view again; but half an hour before the egress, the surface of the sun being very clear and unagitated, he had a well-defined view of the little spot for fifteen minutes, especially when he employed a glass not deeply colored, and he exhibited it to two other persons. At this time, he found it at the northeast of Mercury, although it had been at the north in the morning. M. Schenck was not able, with the closest attention, to observe the egress of this little point from the disk of the sun, immediately after that of the planet. He was of opinion that the satellite was situated a little behind Mercury, and was nearer to the sun than the planet.

M. Schumacher does not think that M. Schenck really saw a satellite of Mercury, but ascribes the appearance to a minute solar spot.

Nothing of this kind, so far as we have learned, was seen during the late transit; but it would not seem difficult to distinguish a

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* Astr. Trs. VI, 115.

† Astron. Nach. No. 228; Bib. Univers. t. 5, p. 88.

well-defined, round black spot, such as the one in question is described to have been, from the irregular, ill-defined, and lighter colored object which a solar spot, however minute, would present to the eye of the observer.

P. S. Since the foregoing was in type, we have received a statement of the observations made at Cambridge observatory by Messrs. Bond, and at the Philadelphia High School observatory by Professor Kendall.

At Cambridge, where the ingress was lost, the contacts at the *egress* were as follows:—

	Sidereal time.			*Mean solar time.*		
	h.	m.	s.	h.	m.	s.
Internal contact, . . .	9	8	59	6	2	32
External " . . .	9	12	4·5	6	5	37

At Philadelphia, the following results were obtained.

	Sidereal time.			*Mean solar time.*		
	h.	m.	s.	h.	m.	s.
1st External contact, .	2	26	28·5	11	21	4·27
1st Internal do. .	2	29	6·6	11	23	41·94
2d Internal do. .	8	52	55·3	5	46	27·76
2d External do. .	8	56	25·8	5	49	57·69

ART. XVII.—*Bibliographical Notices.*

1. *Narrative of the United States Exploring Expedition during the years* 1838, 1839, 1840, 1841, 1842; by CHARLES WILKES, U. S. N. Commander of the Expedition. 5 Vols. with an Atlas.—Philadelphia, 1845, Lea & Blanchard.—These noble volumes are honorable alike to the country and the expedition whose history they relate. In style of execution, they have not been exceeded in this country, and the numerous engravings are by our best artists. The work abounds in strange incidents both by sea and land, which throw unusual life and interest into the valuable details of facts presented, regarding the features, productions and people of the various lands visited.

The progress of the expedition during its absence, has been from time to time noticed in this Journal, and a connected outline of its course and results has been given since its return, in Volume XLIV, page 393. Besides the descriptions of men and manners, and a large amount of geographical and statistical information, the volumes contain much that is of scientific interest, and especially so to the geologist. The fine illustrations and descriptions of the island of Hawaii, lay open to the eye that vast region of volcanic action, and with their guidance and aid, the reader may enjoy the terrors of the scene, without experiencing its dangers; and the accurate surveys made of Kilauea, the summit crater of Munna Loa, and other smaller craters, together with the course of the eruption of 1840, give special interest to this part of the work. We might fill many sheets of this Journal with facts of interest regarding the various countries explored, the currents and winds of the ocean and other phenomena observed during a long cruise over the wide world; but for the present we confine ourselves to extracts from or abstracts of the observations of Capt. Wilkes on the Antarctic ice and and land, and more particularly on the formation of icebergs in those regions, with occasional notices of connected topics, and referring our readers for a general view to the full abstract already cited from Vol. XLIV, of the general objects and results of the expedition.

Before we proceed farther, we wish to remind our readers that other works, perfectly distinct from the narrative, are in preparation in their various departments, by the men of science, aided by the able artists who accompanied the expedition, and we are happy in the assurance, afforded by the splendid illustrations of the narrative, that those of the scientific works will be equally worthy of the occasion.

The gentlemen alluded to above, were—Messrs. N. Hale, Philologist; C. Pickering and T. R. Peale, Naturalists; J. P. Couthouy, Conchologist; J. D. Dana, Mineralogist and Geologist; W. Rich, Botanist; J. D. Breckenridge, Horticulturist; and J. Drayton and A. T. Agate as Draughtsmen; there were also several assistants.

The squadron consisted of the Vincennes, commanded by Capt. Wilkes; the Peacock, by Capt. Hudson; the Porpoise, by Lieut. Ringgold; the Relief, store-ship, by Capt. Long; the Sea Gull, by Mr. Reed; and the Flying Fish, by Mr. Knox. The Sea Gull was lost with all her officers and crew off Cape Horn, and the Peacock, on her return at the close of the expedition, was stranded and totally lost on a bar at the mouth of the Columbia River, but her officers and people were all saved, although with a total loss of every thing but life.

We now proceed with our citations regarding the ice and some other topics. In the second cruise towards the South Pole, on the 10th of January, 1840, in lat. 61° 8′ S., the Vincennes encountered the first iceberg, the sea water being at 32°; they were close to it and found it a mile long, and one hundred and eighty feet high above water; a second iceberg was discovered at thirty miles, and a third at sixty miles south of the first. These islands were cavernous and fissured by the action of the sea, as if about to be rent asunder, and they were apparently stratified at a high angle to the horizon. Many other icebergs of similar character occurred, and as they increased in number the sea grew smoother and without apparent motion, until they were stopped by a compact barrier of ice enclosing large square icebergs; the barrier consisted of masses closely packed, and of every variety of shape and size. "The night was beautiful and every thing seemed sunk in sleep, except the sound of the distant and low rustling of the ice, that now and then met the ear." Lat. 64° 11′ S., variation 22° E. The water was of an olive green and there were some faint appearances of distant land. Barom. 29·20 inches; the air at 30° F.; water 32°.

The Porpoise in obedience to orders made Macquarie Island, lat. 54° 44′ S., to look out for signals from the other ships and to leave them in turn. A tremendous surf breaking upon a rock-bound reef, rendered landing all but impossible. Lieut. Eld and the quarter-master, by plunging into the breakers breast high, gained the shore and planted the signals, although none were found. The island is a desolate, inhospitable region, inhabited only by birds, especially by penguins.*

On the 11th and 12th, in lat. 61° 30′ S., long. 161° 5′ E. the first ice islands were seen; newspapers could be read at midnight without artificial light.

Jan. 16 they descried the new continent, and the numerous proofs presented in detail in the narrative leave no doubt that the discovery was real and original; it is impossible within our limits to give the details of evidence; mountains were seen in the distance, over the icebergs which were all light and brilliant, and in great contrast; the vicinity of land was indicated by the flight of birds, with whales and penguins. The Peacock sounded with 850 fathoms without finding bottom. The field ice is composed of a vast number of pieces, the smallest about six feet in diameter, the largest sometimes five to six hundred. Most of them,

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* Mr. Eld found them in myriads, the entire sides of the rugged hills being covered with them. As he crossed a ravine and ascended towards their principal roost, his astonishment increased at every step. Such was the emulous din of bird voices that the human voice was scarcely audible. They appeared to be incensed at the stranger's intrusion, and manifested their ire by snapping and biting both the trowsers and flesh, pinching it violently.

As he wanted specimens, he began by kicking them down the precipice, and knocked his assailants on the head, and when he left them and a few eggs, in order to ascend the hill higher, two albatrosses having failed to make any impression on the dead birds, bore off two of the eggs in their beaks, although they were of the size of those of a goose. These eggs, doubtless those of the penguin, were found in the nest, which was only a small hole in the earth, just large enough to hold an egg or two, "with little or no grass, sticks or any thing else to form a nest of."

On a still higher hill of volcanic rock the nests, with a young one or two in each, were within two feet of each other. One of the parent birds kept watch on the nest while their young ones, resembling goslings covered with down, endeavored to nestle under their small wings. These penguins (the *Eudyptes chrysocome*) are from 16 to 20 inches high, breast white, back nearly black, the rest of a dark dun color, excepting the head, which has a graceful plume of four or five yellow feathers on each side of the head. They stand in rows like Lilliputian soldiers. There were also penguins without plumes, and green paroquets with a small red spot on the head.

especially the largest, were covered with about eighteen inches of snow. The whole at a distance appeared like a vast level field, composed of shapeless, angular masses of every possible figure, enclosing here and there a table-topped iceberg.

The Vincennes was making rapid headway with a heavy sea, when in an instant all was perfectly still and quiet. The sleepers were awakened by the sudden transition, and all rushed on deck, for it was quite evident that they were embayed within a line or barrier of ice, and as they were proceeding rapidly in an impenetrable fog, it was realized that they might be running to destruction, for the ice was soon made on either tack, and the rustling sound occasioned by its movement was distinctly heard. It cost the Vincennes several hours of maneuvering to extricate herself from this perilous situation.

On the 19th of January the sun and moon both appeared above the horizon at the same time, and each throwing its light abroad. The moon was nearly full. The sun with his deep golden rays illuminated the icebergs and distant continent, while the moon in the opposite horizon tinged the vicinal clouds with its silvery light.*

They now encountered icebergs of magnificent dimensions, one-third of a mile long, and one hundred and fifty to two hundred feet high, with perfectly smooth sides; some were arched and cavernous, the sea thundering into these deep recesses, and the birds flying in and out as in ruined castles, and abbeys, and natural caverns, "while here and there a bold projecting bluff crowned with pinnacles and turrets, resembled some Gothic keep. Every noise on board, even our own voices, was reverberated from the pure white walls, whose tabular masses resembled the most beautiful alabaster." "If an immense city of ruined alabaster palaces can be imagined, of every variety of shape and tint, and composed of huge piles of buildings grouped together, with long lanes or streets winding irregularly through them, some faint idea may be formed of the grandeur and beauty of the spectacle. The time and circumstances under which we were threading our way through them, we knew not to what end, left an impression of these icy and desolate regions that can never be forgotten."

Jan. 22. "It was now during fine weather one continued day," obscured occasionally by snow squalls. "The bergs were so vast and inaccessible that there was no possibility of landing upon them." The observations of the Peacock were particularly interesting, especially as

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* In a smooth sea they witnessed (Jan. 20) a fine combat between a large whale and a ferocious fish called a killer, which had seized the whale by the lower jaw, and despite of the desperate efforts of the powerful animal, filled the sea with foam and blood, and when the whale leaped twenty feet out of the water, with open mouth, the killer still kept hold and probably prevailed. The whales appear to be attracted to these seas by the squids and shrimps.

she was not prepared beyond what is usual with our vessels of war, for the dangers that were to be encountered, having no planking, extra fastenings, or other preparations for these icy regions. In the same water in which the Vincennes had been embayed, the Peacock prepared with a line of fourteen hundred fathoms, found bottom with five hundred fathoms; there was blue and slate colored mud; a piece of stone was attached to the lead, which had a bruise upon it, as if it had struck upon hard rock; the remainder of the line had evidently lain upon the bottom. After sailing a short distance the soundings were three hundred and twenty fathoms, thus shallowing one hundred and eighty, and indicating an approach to a shore; the surface temperature 32°, and that at the bottom $27\frac{1}{2}$°; dip of the needle, 86° 16′. The feeling on board the ship was that of intense gratification, as it was now considered to be certain that a terra firma (not an island merely) had been discovered.*

Jan. 24. At a short distance soundings were found at eight hundred fathoms. The Peacock was now approaching to great perils. At 8*h*. 30*m*. A. M. in attempting to avoid some ice under the bow, the stern came "so forcibly in contact with another mass of ice, that it seemed from the shock as if it were entirely stove in," and the rudder with its appendages was so much injured as to make a considerable angle with the keel, and thus to become entirely useless.

The ship was now rapidly entering the ice and could not be steered by her sails; fresh shocks were received almost every moment, and every blow threatened instant destruction. An ineffectual attempt was made to repair the rudder by rigging a stage over the stern, and it was eventually unshipped and hoisted aboard. "In the meantime, the position of the vessel was every instant growing worse and worse, surrounded as she was by masses of floe-ice, and driving farther and farther into it towards an immense wall-sided iceberg. All attempts to get the vessel on the other tack failed, in consequence of her being so closely encompassed." They attempted, therefore, to bring her head round by hanging her to an iceberg by the ice anchors. Just at the moment when, the anchor having been attached, "the hawser was passed on board, the ship took a start so suddenly astern, that the rope was literally dragged out of the men's hands before they could get a turn around the bits."

* A penguin forty-five inches long from the tip of the tail to the bill, thirty-seven inches across the flippers and thirty-three for the circumference of the body, approached without any sign of fear, but was knocked down by the boat-hook, and on recovering showed great resentment by fighting or noise. On being duly prepared for the museum at Washington, thirty-two small pebbles were found in his craw.

The ship now drove astern into the midst of the huge masses of ice, striking the rudder a second time, which gave the finishing stroke. The wind freshening and the floe-ice setting in, the sails were furled, and spars rigged down the ship's sides as fenders. In attempting to plant the ice anchors, the pieces of floating ice ground against each other so violently that the boats proved almost unmanageable;—but the ice anchors were at last planted, and the hawser hauled taught, and for a short time they held fast; but the ice continued to close in rapidly upon them, grinding, crushing and carrying away the fenders—when the anchors broke loose and the ship drove towards an ice island, vast, perpendicular, and as high as the mast-head. The anchors again held for a moment, but the whole body of ice to which they were attached came in contact with them, and the ship struck quartering upon a field of ice which lay between her and the great ice island; but it proved only a temporary defence, for, grinding along the ice, she went nearly stern foremost and struck with her larboard quarter upon the ice island, with a tremendous crash and much damage—but a great and happy rebound, with the aid of the jib and other sails, carried her clear of the ice island and forced her into a small opening—"when, before she had moved half her length, an impending mass of ice and snow fell in her wake. Had this fallen only a few minutes earlier, it must have crushed the vessel to atoms!" As she struck near the southern termination of the ice island, she was soon clear of it—the ice drifted by and she could be worked by her sails. But the stormy aspect of the sky presented the fear of shipwreck and of perishing by the water or the cold. But dinner was piped as usual, and although the vessel was fast in the ice, they managed by swinging the yards to keep her head in the right direction: but she was laboring in the swell with the ice grinding and thumping against her on all sides, and every moment something fore or aft was carried away—chain-bolts, bobstays, bowsprit shrouds—even the anchors were lifted, coming down with a surge that carried away the eyebolts and lashings, and left them to hang by the stoppers;—the cut-water also was injured, and every timber seemed to groan. The dangers that attended the boats were likewise imminent; while executing the hazardous service of fixing the ice anchors, they were almost crushed, and Mr. Eld and his assistants escaped with the utmost difficulty.

At 4 P. M., the ship being fast in the ice and the wind directly in from the seaward, the ice anchors were again run out, and soon after, the ice clearing away from the stern, they were able to unship the rudder, and took it on board in two pieces, when all the carpenters were immediately employed upon it.

It soon began to snow violently and their hope of deliverance grew more faint, especially as the ship was now forced back into the ice to leeward and towards the massive walls of the berg; but by great exertions her head was again pointed seaward, when they were soon wedged between two large masses of ice. The sea rose—the wind increased and threatened a gale, and they strove by every means to push the ship forward; but the ice floes were now of large dimensions, and the increased sea rendered it doubly dangerous, while the heavy shocks made them fear that the ship's bows would be forced in, and the continual grinding and thumping on the ship were most painful. "The hope of extricating her lessened every moment, for the quantity of ice between them and the sea was increasing, and the ship evidently moved with it to leeward." This most trying emergency was met by Captain Hudson with such coolness, perseverance, and presence of mind, as commanded the admiration and confidence of all, and sustained hope when it was almost sinking in despair.

On the afternoon of January 25th, the sea increased, the ship frequently struck, and they were fast grinding away her bows; but the only chance was to drive her out, and all the canvass was set to force her through. By 4 o'clock they had passed the thick and solid ice and were in clear water, without a rudder, the gripe gone, and, as was afterwards ascertained, the stem ground down to within an inch and a half of the wood ends.

In the meantime the carpenters had repaired the rudder—Mr. Dibble having left his sick bed for that purpose, and he and his crew worked twenty four hours without intermission. The rudder was again shipped and being hung by the only two braces that remained, they escaped from a bay about thirty miles in extent by the only remaining opening, which was not more than a quarter of a mile wide: this they passed at 2 P. M. in a snow storm, "and felt grateful to God for their providential escape."

The ship was so thoroughly crippled as to be unseaworthy, especially in such a dangerous service, and it was very wisely resolved to return to the north and find at Sydney, in Australasia, both a refuge and the means of making repairs.

Even this condensed abstract will fully justify the concluding remarks of Capt. Wilkes:—"Such were the dangers and difficulties from which the Peacock, by the admirable conduct of her officers and crew, directed by the consummate seamanship of her commander, was enabled, at this time, to escape. There still remained, however, thousands of miles of a stormy ocean to be encountered, with a ship so crippled as to be hardly capable of working, and injured to such an extent in her hull as to be kept afloat with difficulty."

The Vincennes and the Porpoise, as well as the Flying Fish, also combated the perils of this very dangerous navigation. The Vincennes passed the place where the Peacock entered, and found no opening beyond. She observed a group of tabular and stranded icebergs, and by midnight on the 23d of January, (1840,) reached the solid barrier, while all approach to the land was entirely cut off on the east and west by the close packing of the icebergs. There was an indentation of the coast twenty five miles deep, which Capt. Wilkes penetrated about fifteen miles without reaching its termination: he called it Disappointment Bay. Its lat. was 67° 4′ 30″ S.—long. 147° 30′ W.

They had fine weather, and many birds appeared about the ship. They took the opportunity to fill nineteen tanks with ice—having first allowed the salt water to drip from it, and it proved very potable.

They met with snow storms and thick weather, so that they could not always run, even with a fair wind, and when they did it was with extreme hazard on account of the floating ice; but as long as they could see the fixed barrier they persevered. On the 28th, in beautifully clear weather, they passed through many tabular icebergs—one hundred being in view at once, and of great dimensions—being from a fourth of a mile to three miles in length. Capt. Wilkes had taken the precaution to make a chart of the icebergs as he met them; and he was surprised at the great number which he had passed and which still surrounded them. The land was plainly in view, but he felt his situation to be extremely critical, as a gale was evidently coming on, with the barometer falling, and destruction appeared before them unless they effected a retreat. This they attempted, but their path was thickly beset with their floating enemies, many of large size and near at hand, and perpetually nearing. To return towards the land was out of the question, and no alternative remained but to keep a good look-out and dash on.

"At 8 P. M. it began to blow very hard, with a violent snow storm circumscribing our view, and rendering it impossible to see more than two ship's lengths ahead. The cold was severe, and every spray that touched the ship was immediately converted into ice. At 9 P. M., the barometer still falling and the gale increasing, we reduced sail to close reefed fore and main topsails, reefed foresail and trysails, under which we passed numerous icebergs, some to windward and some to leeward of us. At 10*h.* 30*m.* we found ourselves thickly beset with them, and had many narrow escapes: the excitement became intense—it required a constant change of helm to avoid those close aboard, and we were compelled to press the ship with canvass in order to escape them, by keeping her to windward. We thus passed close along their weather sides, and distinctly heard the roar of the surf dashing against them.

We had, from time to time, glimpses of their obscure outline, appearing as though immediately above us. After many escapes I found the ship so covered with ice, and the watch so powerless in managing her, that a little after midnight, on the 29th, I had all hands called. Scarcely had they been reported on deck, when it was known to me that the gunner, Mr. Williamson, had fallen, broken his ribs, and otherwise injured himself on the icy deck.

"The gale at this moment was awful. We found we were passing large masses of drift ice, and ice islands became more numerous. A little after 1 o'clock it was terrific, and the sea was now so heavy that I was obliged to reduce sail still further:—the fore and main topsails were clewed up; the former was furled, but the latter being a new sail, much difficulty was found in securing it. A seaman, by the name of Brooks, in endeavoring to execute the order to furl, got on the lee yard-arm, and the sail, having blown over the yard, prevented his return. Not being aware of his position until it was reported to me from the forecastle, he remained there some time. On my seeing him, he appeared stiff and clinging to the yard and lift. Spilling lines were at once rove, and an officer and several men went aloft to rescue him; which they succeeded in doing by passing a bow-line around his body and dragging him into the top. He was almost frozen to death. Several of the men were completely exhausted by cold, fatigue and excitement, and were sent below. This added to our anxieties, and but little hope remained to me of escaping. I felt that neither prudence nor foresight could avail in protecting the ship and crew. All that could be done was to be prepared for any emergency by keeping every one at his station.

"We were swiftly dashing on, for I felt it necessary to keep the ship under rapid way through the water, to enable her to steer and work quickly. Suddenly, many voices cried out—'Ice ahead!' then, 'On the lee bow!' and again, 'On the lee bow and abeam!' All hope of escape seemed in a moment to vanish. Return we could not, as large ice islands had been passed to leeward; so we dashed on, expecting every moment the crash. The ship in an instant from having her lee guns under water rose upright; and so close were we passing to leeward of one of these huge islands, that our trysails were almost thrown aback by the eddy wind. The helm was put up, but the proximity of those under our lee made me keep my course. All was now still, except the distant roar of the wild storm, that was raging behind, before and above us: the sea was in great agitation, and both officers and men were in the highest degree excited.

"The ship continued her way, and as we proceeded a glimmering of hope arose, for we accidentally had lit upon a clear passage between two large ice-islands, which in fair weather we should not have dared to venture through. The suspense endured while making our way through them was intense, but of short duration; and my spirits rose, as I heard the whistling of the gale grow louder and louder before us as we emerged from the passage. We had escaped an awful death and were again tempest-tost.

"We encountered many similar dangers at night. At half past 4 A. M., I found we had reached the small open space laid down on my chart, and at 5 o'clock I hove to the ship. I had been under intense excitement and had not been off the deck for nine hours, and was now thankful to the Providence that had guided, watched over and preserved us. Until 7 A. M., all hands were on deck, when there was some appearance of the weather moderating and they were piped down. By noon we felt satisfied that the gale was over, and that we had escaped, although it was difficult to realize a sense of security, when the perils we had just passed through were so fresh in our minds and others still impending."

On the morning of the 30th, which was very fine, the Vincennes again made for the icy barrier, through a smooth sea, with the land fully in sight and the encouraging hope that they might reach it. Still so many icebergs were in view, that a straight line drawn in any direction would have cut a dozen of them in the same number of miles, and the wonder of all was excited, that they could ever have passed through them unharmed.

With all sail set, they soon reached water that was clear quite to the shores or icy barrier, along which they coasted and were impelled at the rate of nine or ten miles an hour. They were in a bay formed partly by rocks and partly by stranded ice islands, extending about five miles northward of their position. The gale increased and the space was so narrow that they could not reduce their canvass before it was necessary to come about.

"In this way we approached within half a mile of the dark volcanic rocks, which appeared on both sides of us, and saw the land gradually rising beyond the ice to the height of 3000 feet and entirely covered with snow. It could be distinctly seen extending to the E. and W. of our position fully 60 miles. I made the bay in lat 66° 5′ S.; and now that all were convinced of its existence, I gave the land the name of the Antarctic Continent. We found a hard bottom at 30 fathoms."

A gale now came on in the form of a snow storm with sharp icicles piercing like needles, and it was necessary to clear the bay, as it was out of the question to run the gauntlet again among the icebergs. It blew tremendously, with a short sea implying a current.

On the 31st, at 1 o'clock, A. M., they passed ice islands and just escaped the field ice; the scene of the former gale was renewed—only "we were now passing to and fro among icebergs, immediately to the windward of the barrier, and each tack brought us nearer to it." The navigable space growing more and more narrow, they tacked and stood N. N. W. and passed icebergs of all dimensions and heavy floe-ice. After the gale had lasted 30 hours* it began to abate, when they again stood southward, and the commander decided again to seek the bay (Parier's) which they had left and still farther to pursue the great object of obtaining a footing upon the terra firma of the new continent, although the medical officers and a majority of the other officers of the ship—on account of the bad health and exhaustion of the crew, recommended a return to the north.

On the 2d of February, at 3 P. M., they were within two and a half miles of "the icy cliffs by which the land was bounded on all sides. They were from one hundred and fifty to two hundred feet in height, quite perpendicular, and there was no appearance whatever of rocks; all was covered with ice and snow." A long range of stranded weather-beaten icebergs, extended far to the west, but soundings were not obtained at one hundred and fifty fathoms. "No break in the icy barrier, where a foot could be set on the rocks, was observable from aloft. The land still trended to the west as far as the eye could reach, and continued to exhibit the same character as before." The high land was seen again in the afternoon, but the ice barrier prevented any nearer approach. Snow rendered the ship damp and uncomfortable; the sick list was increasing, and the days were becoming shorter. They continued to coast along the icy barrier about one hundred and fifty feet high, beyond which the high land could be well distinguished. The barrier now trended south, and the sea was studded with icebergs.

On the 9th the weather was very fine; the outline of the land was visible, and the icy barrier was very beautiful. At midnight there was a splendid display of the aurora australis, extending all around the northern horizon, from W. by N. to E. N. E. The spurs or brushes of light, frequently reached the zenith, converging to a point near it. The barrier ice was approached in many places and land was distinctly seen, eighteen to twenty miles distant, bearing S. S. E. to S. W.; a lofty mountain range covered with snow, though showing many ridges and indentations. The land was in about 65° 20′ S., and its trending nearly E. and W.

The line of the icy barrier was generally uniform, although it was occasionally pierced with deep bays. Some icebergs were seen with de-

* The barometer sunk to 28·59 inch.

cided spots of earth upon them. On the 13th the land appeared high, rounded and covered with snow, resembling that first discovered, and seemed to be bound by perpendicular icy cliffs. On the 14th the land was very distinct—seventy five miles of coast being in view at once, and the land three thousand feet high.*

They landed on one of the largest of the icebergs and found imbedded in it, in places, boulder-stones, gravel, sand, and mud or clay. The largest specimens were of red sandstone and basalt, and there was an icy conglomerate—large pieces of rocks being united by very hard and flinty ice. The largest boulder was about five or six feet in diameter, but being in an inaccessible position it could not be obtained. Many specimens were procured, and all were eager to acquire portions of the Antarctic continent. "In the centre of this iceberg was a pond of most delicious water, over which was a scum of ice about ten inches thick. This pond was three feet deep, extending over an area of an acre, and contained sufficient water for half a dozen ships. The temperature of the water was 31°." They remained upon this iceberg several hours, and the men amused themselves by sliding down hill. Around the iceberg, were many species of zoophytes. On the 15th they passed many icebergs much discolored with earth and stones.

Whales were numerous as well as penguins, Cape pigeons and other birds; the icebergs were covered with penguins. On the 17th, the barrier was seen running N. and S. as far as the eye could reach; they had penetrated a bay fifty or sixty miles deep, and having coasted along its southern side they returned by the northern, the weather giving ominous indications. Many whales were met with and their curiosity seemed awakened by the ship; they were very large fin-backs, and familiarly approached the vessel, blowing at the same time like locomotives, and their presence was any thing but agreeable.

The aurora was again seen in great splendor in a perfectly clear sky, "darting from the zenith to the horizon in all directions, in the most brilliant coruscations; it flashed in brilliant pencilings of light, like sparks of electric fluid in vacuo, and reappeared again to vanish; forming themselves into one body like an umbrella, or fan, shut up; again emerging to flit across the sky with the rapidity of light, they showed all the prismatic colors at once or in quick succession; even the sailors exclaimed in admiration of their beauty, which was best seen when the observer was lying on his back and looking up." There was no effect on the electrometer.

"Large icebergs had now become very numerous and the ship passed through the thickest of them; upwards of one hundred could be count-

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* By approximate measurement.

ed at a time, without the aid of a glass, and some of them several miles long." On the 18th, there were snow-flakes in six-rayed stars; temperature, 28°; barometer, 28·76 inch.

On the 19th the barrier trended more to the north; deep bays were frequent, out of which it was often necessary to return almost to the point of entrance, and the smoothness of the sea, which was narrowed by the ice so as to be like a river, produced some apprehension that the barrier might preclude a retreat; but an increasing swell, indicating their approach to a clear sea, relieved this anxiety. It appears from the observations of the squadron, both in the present season and the last, that very little change takes place in the line of ice.*

"It may be inferred that the line of perpetual congelation exists in a lower latitude in some parts of the southern hemisphere than in others. The icy barrier retreats several degrees to the south of the Antartic Circle to the west of Cape Horn, while to the eastward it in places advances to the northward of that line, which is no doubt owing to the situation of the land. From the great quantities of ice to be found drifting in all parts of the ocean in high southern latitudes, I am induced to believe that the formation of the ice-islands is much more rapid than is generally supposed. The manner of their formation claimed much of my attention while among them, and I think it may be explained satisfactorily and without difficulty. In the first place, I conceive that ice requires a nucleus, whereon the fogs, snow, and rain, may congeal and accumulate; this the land affords. Accident then separates part of this mass of ice from the land, when it drifts off, and is broken into many pieces, and part of this may again join that which is in process of formation. The sketch in Chapter IX. has already given the reader some idea of its appearance in this state.

"From the accumulation of snow, such a mass speedily assumes a flat or table-topped shape, and continues to increase. As these layers accumulate, the field-ice begins to sink, each storm (there of frequent occurrence) tending to give it more weight. The part which is now attached to the land remains aground, whilst that which is more remote, being in deep water, is free to sink. The accumulated weight on its outer edge produces fissures or fractures at the point where it takes the ground, which the frosts increase; thus separated, the surface again becomes horizontal, and continues to receive new layers from snow, rain, and even fogs, being still retained to the parent mass by the force of attraction. The fogs have no small influence in contributing to the accumulation: some idea may be formed of the increase from this cause, from the fact, that during a few hours the ice accumulated to the thickness of a quarter of an inch on our rigging and spars, though neither rain nor snow fell. It may, therefore, I think, be safely asserted that these icebergs are at all times on the increase; for there are few days, according to our experience in this climate, in which some mode of precipitation does not prevail in these high latitudes, where, according to our observations, ice seldom melts. The temperature of even the summer months being rarely above the freezing point, masses of a thousand feet in thickness might require but few years to form. Icebergs were seen in all stages of formation, from five to two hundred feet above the surface, and each exposed its stratification in horizontal

* The remainder of this chapter is so important that we give it without abridgment, that the author may present his conclusions in the most ample manner.

layers from six inches to four feet in thickness. When the icebergs are fully formed, they have a tabular and stratified appearance, and are perfectly wall-sided, varying from one hundred and eighty to two hundred and ten feet in height. These were frequently found by us in their original situation, attached to the land, and having the horizontal stratification distinctly visible.

"In some places we sailed for more than fifty miles together, along a straight and perpendicular wall, from one hundred and fifty to two hundred feet in height, with the land behind it. The icebergs found along the coast afloat were from a quarter of a mile to five miles in length; their separation from the land may be effected by severe frost rending them asunder, after which the violent and frequent storms may be considered a sufficient cause to overcome the attraction which holds them to the parent mass. In their next stage they exhibit the process of decay, being found fifty or sixty miles from the land, and for the most part with their surfaces inclined at a considerable angle to the horizon. This is caused by a change in the position of the centre of gravity, arising from the abrading action of the waves.

"By our observations on the temperature of the sea, it is evident that these ice-islands can be little changed by the melting process before they reach the latitude of 60. The temperature of the sea (as observed by the vessels going to and returning from the south) showed but little change above this latitude, and no doubt it was at its maximum, as it was then the height of the summer season.

"During their drift to the northward, on reaching lower latitudes, and as their distance from the land increases, they are found in all stages of decay; some forming obelisks; others towers and Gothic arches; and all more or less perforated; some exhibit lofty columns, with a natural bridge resting on them of a lightness and beauty inconceivable in any other material.

"While in this state, they rarely exhibit any signs of stratification, and some appear to be formed of a soft and porous ice; others are quite blue; others again show a green tint, and are of hard flinty ice. Large ice-islands are seen that retain their tabular tops nearly entire until they reach a low latitude, when their dissolution rapidly ensues; whilst some have lost all resemblance to their original formation, and had evidently been overturned. The process of actually rending asunder was not witnessed by any of the vessels, although in the Flying-Fish, when during fogs they were in close proximity to large ice-islands, they inferred from the loud crashing, and the sudden splashing of the sea on her, that such occurrences had taken place. As the bergs gradually become worn by the abrasion of the sea, they in many cases form large overhanging shelves, about two or three feet above the water, extending out ten or twelve feet; the under part of this projecting mass exhibits the appearance of a collection of icicles hanging from it. The temperature of the water when among the icebergs, was found below or about the freezing point.

"I have before spoken of the boulders imbedded in the icebergs. All those that I had an opportunity of observing, apparently formed a part of the nucleus, and were surrounded by extremely compact ice, so that they appear to be connected with that portion of the ice that would be the last to dissolve, and these boulders would therefore in all probability, be carried to the farthest extent of their range before they were let loose or deposited.

"The ice-islands, on being detached from their original place of formation by some violent storm, are conveyed to the westward by the southeast winds which are prevalent here, and are found, the first season after their separation, about seventy miles north of the barrier. This was inferred from the observations of both the Vincennes and Porpoise, the greatest number having been found about that distance from the barrier. That these were recently detached is proved by their stratified appearance; while those at a greater distance had lost their primitive form, were much worn, and showed many more signs of decay. Near the extreme point of the barrier visited, in longitude 97° E., latitude 62° 30′ S., and where it begins to trend to the westward, vast collections of these islands were encountered. From this point they must pass to the northward during the next season, partly influenced by the current, and partly scattered by the prevailing winds, until they reach the sixtieth degree of latitude, when they encounter the easterly and northeasterly streams that are known to prevail, which carry them rapidly to the north.

"Our data for their actual drift, though not altogether positive, are probably the best that can be had, and will go far towards ascertaining the velocity of their progress to lower latitudes; our observations also furnish some estimate of the time in which they are formed. On our way south, we did not fall in with ice-islands until we reached latitude 61° S. The Peacock was the first to return, and nearly upon the track by which we had gone south; the last seen by her was in 55° S. The Vincennes, on her return fifty days later, saw them in 51° S. The Porpoise, about the same time, in 53° S. The observation in the Vincennes gives a distance of ten degrees of latitude, or six hundred miles to be passed over in fifty days, which would give about half a mile an hour; or, taking the Peacock's observations, a more rapid rate would be given, nearly three-fourths of a mile. Many icebergs were met in the latitude of 42° S., by outward-bound ships to Sydney, in the month of November; these, I learned, were much worn, and showed lofty pinnacles, exhibiting no appearance of having ever been of a tabular form. These no doubt are such as were detached during a former season, and being disengaged from the barrier, would be naturally, early the next season, drifted by the easterly current as well as the westerly wind, and would pursue the direction they give them. They would therefore be driven to the northeast as far as the southwest winds prevail, and when these veer to the westward would receive an easterly direction. It is where these winds prevail that they are most frequently found by the outward-bound vessels—between the latitudes of 40° and 50° S.

"Respecting the period of time required for the formation of these ice-islands, much light cannot be expected to be thrown on the subject; but the few facts derived from observations lead to some conclusions. Many of them were measured, and their altitude found to be from fifty to two hundred and fifty feet; eighty distinct stratifications were counted in some of the highest, and in the smallest thirty, which appeared to average a little more than two feet in thickness. Supposing the average fall of snow in these high latitudes to be an inch a day, or thirty feet a year, the largest icebergs would take more than thirty years to form. They were seen by us in all the stages of their growth, and all bore unequivocal marks of the same origin. The distance from the land at which they were forming, fully satisfied me that their fresh water could be derived only from the snows, &c.

"The movement of the ice along the coast is entirely to the westward, and all the large ranges of ice-islands and bergs were found in that direction, while the eastern portion was comparatively free from it. A difference was found in the position of the floe-ice by the different vessels, caused rather by the wind than by the tide. When the Vincennes and Porpoise passed the opening by which the Peacock entered, it was found closed, although only twenty-four hours had elapsed. It has been seen that the ice had much movement during the time the Peacock was beset by it, and the bay was all but closed when she effected her escape. Another instance occurred, where the Porpoise, in about the longitude of 130° E., found the impracticable barrier a few miles further south than the Vincennes did six or seven days after; but this fact is not to be received as warranting any general conclusion, on account of the occurrence of southeast gales during the intermediate time. The trials for currents have, for the most part, shown none to exist. The Porpoise, it is true, experienced some, but these were generally after a gale. If currents do exist, their tendency is westward, which I think the drift of the ice would clearly prove. The difference between the astronomic positions and those given by dead-reckoning, was of no avail here as a test,* for the course of the vessels among the ice was so tortuous, that the latter could not be depended upon.

"The winds which prevail from the southwest to the southeast occasionally bring clear weather, interrupted by flurries of snow; the north wind is light, and brings thick fogs, attended by a rise of temperature. Extremes of weather are experienced in rapid succession, and it is truly a fickle climate.

"The evidence that an extensive continent lies within the icy barrier, must have appeared in the account of my proceedings, but will be, I think, more forcibly exhibited by a comparison with the aspect of other lands in the same southern parallel. Palmer's Land, for instance, which is in like manner invested with ice, is so at certain seasons of the year only, while at others it is quite clear, because strong currents prevail there, which sweep the ice off to the northeast. Along the Antarctic Continent for the whole distance explored, which is upwards of fifteen hundred miles, no open strait is found. The coast, where the ice permitted approach, was found enveloped with a perpendicular barrier, in some cases unbroken for fifty miles. If there was only a chain of islands, the outline of the ice would undoubtedly be of another form; and it is scarcely to be conceived that so long a chain could extend so nearly in the same parallel of latitude. The land has none of the abruptness of termination that the islands of high southern latitudes exhibit; and I am satisfied that it exists in one uninterrupted line of coast, from Ringgold's Knoll, in the east, to Enderby's Land, in the west; that the coast (at longitude 95° E.) trends to the north, and this will account for the icy barrier existing, with little alteration, where it was seen by Cook in 1773. The vast number of ice-islands conclusively points out that there is some extensive nucleus which retains them in their position; for I can see no reason why the ice should not be disengaged from islands, if they were such, as happens in all other cases in like latitudes. The formation of the coast is different from what would probably be found near islands, soundings being obtained in comparatively shoal water; and the color of the water also indicates that it is not like other southern lands, abrupt and precipitous. This cause is sufficient to retain the huge masses of ice, by their being attached by their lower surfaces instead of their sides only.

"Much inquiry and a strong desire has been evinced by geologists, to ascertain the extent to which these ice-islands travel, the boulders and masses of earth they transport, and the direction they take.

"From my own observations, and the information I have collected, there appears a great difference in the movements of these vast masses; in some years, great numbers of them have floated north from the Antarctic Circle, and even at times obstructed the navigation about the capes. The year 1832 was remarkable in this respect; many vessels bound round Cape Horn from the Pacific, were obliged to put back to Chili, in consequence of the dangers arising from ice; while, during the preceding and following years, little or none was seen: this

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* The fact of there being no northerly current along this extended line of coast, is a strong proof in my mind of its being a continent, instead of a range of islands.

would lead to the belief, that great changes must take place in the higher latitudes, or the prevalence of some cause to detach the ice-islands from the barrier in such great quantities as to cover almost the entire section of the ocean, south of the latitude 50° S. Taking the early part of the (southern) spring, as the time of separation, we are enabled to make some estimate of the velocity with which they move: many masters of vessels have met them, some six or seven hundred miles from the barrier, from sixty to eighty days after this period, which will give a near approximation to our results heretofore stated.

"The season of 1839 and '40 was considered as an open one, from the large masses of ice that were met with in a low latitude, by vessels that arrived from Europe at Sydney: many of them were seen as far north as latitude 42° S.

"The causes that prevail to detach and carry them north, are difficult to assign. I have referred to the most probable ones that would detach them from the parent mass in their formation. Our frequent trials of currents, as has been stated. did not give us the assurance that any existed; but there is little doubt in my mind that they do prevail. I should not, however, look to a surface current as being the motive power that carries these immense masses at the rate they move; comparatively speaking, their great bulk is below the influence of any surface current, and the rapid drift of these masses by winds is still more improbable; therefore I conceive we must look to an under current as their great propeller. In one trial of the deep-sea thermometer, we found the temperature beneath, four degrees warmer than the surface. Off Cape Horn, the under temperature was found as cold as among the ice itself; repeated experiments have shown the same to occur in the Arctic regions. From this I would draw the conclusion that changes are going on, and it appears to me to be very reasonable to suppose, that at periods, currents to and from the poles should at times exist; it is true, we most generally find the latter to prevail, as far as our knowledge of facts extends, but we have not sufficient information yet to decide that there is not a reflow towards the pole; the very circumstance of the current setting from the higher latitudes, would seem a good argument that there must be some counter-current to maintain the level of the waters. These masses, then, are most probably carried away in the seasons when the polar streams are the strongest, and are borne along by them at the velocity with which they move: that these do not occur annually may be inferred from the absence of ice-islands in the lower latitudes; and that it is not from the scarcity of them, those who shared the dangers of the Antarctic cruise, will, I have little doubt, be ready to testify; for, although great numbers of them studded the ocean that year, yet the narrative shows that vast numbers of them were left.

"The specific gravity of the ice varies very much, as might naturally be expected; for while some of it is porous and of a snowy texture, other islands are in great part composed of a compact blue flinty ice. This difference is occasioned by the latter becoming saturated with water, which afterwards freezes.

"On the ice there was usually a covering of about two feet of snow, which in places had upon it a crust of ice not strong enough to bear the weight of a man. Those ice-islands, which after having been once seen, were again passed through immediately after a gale, were observed to be changed in appearance; but though for forty-eight hours a severe storm had been experienced, they had not undergone so great a transformation as not to be recognized. They also appeared to have shifted their position with regard to one another, their former bias and trendings being broken up.

"During our stay on the icy coast, I saw nothing of what is termed pack-ice—that is, pieces forced one upon the other by the action of the sea or currents.

"On the 21st, the weather became unsettled, with light westerly winds, and we made but little progress to the westward. The barrier, at 6 P. M., was seen trending to the westward. In consequence of indications that threatened bad weather, I deemed it useless risk to remain in the proximity of so many ice-islands; and a strong breeze, with squally weather, having already set in, I took advantage of it, feeling satisfied that our farther continuance in this icy region would not only be attended with peril to the ship, but would cause a waste of the time which was demanded by my other duties; and having nearly three thousand miles to sail to our next port (Bay of Islands), I made up my mind to turn the head of the vessel northward.

"I therefore had the officers and crew called aft, thanked them all for their exertions and good conduct during the trying scenes they had gone through, congratulated them on the success that had attended us, and informed them that I had determined to bear up and return north.

"Having only twenty-five days' full allowance of water, I ordered its issue to be reduced to half allowance.

"I have seldom seen so many happy faces, or such rejoicings, as the announcement of my intention to return produced. But although the crew were delighted at the termination of this dangerous cruise, not a word of impatience or discontent had been heard during its continuance. Neither had there been occasion for punishment; and I could not but be thankful to have been enabled to conduct the ship through so difficult and dangerous a navigation, without a single accident, with a crew in as good a condition, if not in a better, than when we first reached the icy barrier. For myself, I indeed felt worse for the fatigues and anxieties I had undergone; but I was able to attend to all my duties, and considered myself amply repaid for my impaired health by the important discoveries we had made, and the success that had attended our exertions."

2. *Prof. W. R. Johnson on the Heating Power of various Coals.*—In the last volume of this Journal, p. 394, we gave a brief notice of the elaborate and valuable "Report" made by Prof. Johnson to the Navy Department, detailing the result of a long series of experiments instituted by him under the authority of government, upon the American coals, as well as some foreign ones. We take the following *resumé* of his labors from a report submitted to the Academy of Natural Sciences of Philadelphia, and published in their Proceedings for February, 1845, p. 202.

Prof. Johnson first enumerates some of the methods which have been hitherto employed by chemists and others, to ascertain the relative heating powers of fuel.

1. *The heating of water*, without converting it into vapor, as practised first by Rumford, and more recently by other experimenters, particularly by Despretz and Dulong. The French chemists assume as the *unit of calorific power*, 1 gramme of water heated 1° centigrade, (1°·8 Fahr.) The number of such units produced by burning 1 gramme of combustible is termed its *calorific efficiency*.

2. *The melting of ice*, as in the calorimeter of Lavoisier and Laplace, also employed by Hassenfratz. The heat of fluidity (135° Fahr.) is here the measure of effect.

3. *The heating of air*, or maintaining a certain difference between an interior room in which combustion is conducted, and an exterior one, kept cool by the open air. The *length of time* such difference is maintained by a given weight of each fuel, is the measure of its efficiency. This is the method of Mr. Marcus Bull.

4. *Combustion in contact with metallic oxides*, measuring the heating power by the weight of metal, reduced on the supposition that the latter is proportionate to the weight of oxygen withdrawn. This is illustrated by M. Berthier's process by litharge.

5. *The reduction of the nitrate or chlorate of potash to the state of a carbonate*, by fusing these salts, and then gradually adding the combustible, till complete saturation has taken place.

6. *The practice of the Cornish engineers*, of measuring the efficiency of fuel by the weight of water, which a given bulk of it (as one bushel) will raise one foot high, when burned under a boiler driving a pumping engine.

7. *The distillation of the coals to ascertain the weight of fixed carbon which they contain*, suggested by the experiments of Mr. Pfyfe, of Edinburgh; the weight of that constituent being supposed to measure the heating power.

8. *Ultimate analysis;* which assumes that the quantity of heat developed by an organic combustible, depends on the heating power of the carbon which it contains, added to that of its excess of hydrogen, above what is required to combine with its oxygen in forming water. This method has been applied by Messrs. Peterson and Schoedler to wood, and by Richardson, Regnault and others, to coals.

9. *The direct or practical trial by evaporation*, as practiced by Messrs. Parkes, Wicksteed, Pfyfe, Schanfhautl and Manby in Great Britain, by Messrs. S. L. Dana, A. A. Hayes, J. A. Francis, and more recently by Prof. J. himself in this country. (The results of the trials last referred to are contained in the Report to the Navy Department on American coals, recently published by Congress.)

10. *The melting of iron* either in a reverberatory or a cupola furnace, the weight of metal fused by one part of combustible being the standard of comparison.

11. *The performance of smith's work of a uniform character*, such as the manufacturing of chains by means of the several varieties of fuel. The number of links of chain formed by a given weight of each coal, is here the measure of useful effect.

The object of the present communication is mainly to exhibit the relation between the results obtained by the *eighth*, and those by the *ninth* method of trial above mentioned.

The existence, in bituminous coals, of variable proportions of nearly pure charcoal, is referred to as furnishing evidence of a want of homogeneousness in this class of bodies. A diversity of results may consequently be expected when ultimate analysis is resorted to for the purpose of establishing a theory of trunsmutations, or of demonstrating what changes have occurred in bringing vegetable substances into the state of bituminous coal. Those who assume *woody fibre* as the sole basis from which it has been derived, do not pretend to prove that the other proximate constituents of vegetables, the resinous matter, for example, and the oily component of seeds, have been wholly removed. Hence analyses of coal applied to this purpose may not always lead to unobjectionable inferences. But as means of determining the calorific power of combustible bodies, they may, especially when performed on average samples, or multiple specimens, afford information both interesting to science and valuable to the arts.

The relation between the calorific power *calculated* from analysis, and the practical heating power decided by evaporating water, is determined for six different varieties of bituminous coals, varying considerably in their composition.

Drawings of the apparatus employed for both these purposes were exhibited, and their action explained. That used in evaporation is so constructed as to determine the proportion of heat expended on the products of combustion, as well as that employed to generate steam.

In applying calculations to the ultimate analyses of coals, as well as to the products of combustion, the atomic weight of carbon is assumed to be six, of oxygen eight, and of nitrogen fourteen times that of hydrogen, in accordance with the recent determinations of Dumas. In calculating evaporative powers, the latent heat of steam is taken at 1030° Fahr., according to Prof. J.'s own investigations of that subject.

In ascertaining the relative efficiencies and values of combustible bodies, with a view to economical applications, it is necessary to take them either as found in nature, or as supplied to commerce, including, of course, whatever impurities they may chance to contain. But in order to deduce general relations between bodies differently constituted, in regard particularly to their combustible constituents, the comparison must be made after deducting the waste, or incombustible matter found in the crude state of the fuel. This principle is applied both to the ultimate analysis and to the evaporative experiments; and hence in the following table both *the calculated evaporative power of the carbon constituent*, (column 15,) and the *total evaporative efficiency by experiment*, (column 18,) are referred to, and calculated for, one part by weight of *combustible matter*.

TABLE *exhibiting the Analyses of several varieties of Bituminous Coal, both into their proximate and their ultimate constituents, with the calculated and the experimental determination of their evaporative powers.*

DESIGNATION OF THE COALS.	Specific gravity.	PROXIMATE ANALYSIS. Composition of the raw coal in 100 parts. Moisture expelled below 250° F.	Sulphur.	Volatile combustible matter.	Fixed carbon.	Earthy matter.	Ratio of fixed to 1 of volatile combustible matter.	ULTIMATE ANALYSIS. Grains of dried coal assayed.	Grains of carbonic acid collected.	Grains of water collected.	By calculation, the *combustible matter* in 100 parts is found to be constituted of— Carbon.	Hydrogen.	Oxygen and nitrogen.	Calculated evaporative power of the carbon alone in one of combustible matter, by Dulong's co-efficient, from water at 212°.	PRACTICAL EVAPORATIVE POWER. Pounds of water from 212° to one of combustible matter. Evaporated from the boiler.	Vaporizable by the heat expended on the gaseous products of combustion.	Total of evaporative efficiency of one part of combustible matter, by experiment on a practical scale.	Difference between the calculated and the experimental efficiency of the combustible matter.
1. Summit Portage Railroad, Cambria County, Penn.	1·3617	0·700	1·500	18·195	64·245	15·360	3·535	7·26	20·62	3·23	91·955	5·867	2·178	11·522	10·238	1·312	11·550	—·028
2. Midlothian, "new shaft," Va.	1·3006	0·914	2·282	29·274	62·050	5·480	1·966	4·57	14·82	2·23	93·620	5·739	0·641	11·731	10·191	1·269	11·460	+·271
3. Newcastle, Eng.	1·2567	1·461		28·312	68·377	1·850	2·415	6·46	19 56	3·21	84·157	5·626	10·218	10·545	9·178	1·720	10·898	—·353
4. Clover Hill, Va.	1·2887	1·277	0·514	28·409	65·425	4·375	2·268	6·05	17·68	2·58	83·393	4·958	11·649	10·445	8·588	1·949	10·537	—·082
5. Scotch,	1·2759	1·365		35·586	60·342	2·707	1·696	7·64	22·60	3·75	82·952	5·607	11·441	10·393	8·868	1·338	10·206	+·187
6. Caseyville, Kentucky, & Cannelton, Indiana,	1·3920	1·150		30·669	44·493	23·687	1·450	4·21	8·96	1·92	76·335	6·663	17·002	9·565	7·734	1·823	9·557	+·008
Averages,	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	10·700	9·133	1·5685	10·701	
7. Osage River, Mo.	1·2000	1·670	0·482	41·348	51·160	5·340	1·237	6·94	19·95	3·69	81.855	6·168	11·977	10·256				
8. Pure bitumen,	1·1558	·000		72·438	24·799	2·761	0·342	8·16	22·60	5·73	77.679	8·023	14·298	9·464				

Remarks.—The evaporative trials were performed by burning about two tons of each kind of coal, under a boiler capable of evaporating 15 cubic feet of water per hour.

The ultimate analysis of coal No. 1, was effected by burning in contact with scale oxide of copper.—2. Analysis by scale oxide, as in No. 1.—3. Analysis by same material as above. The heat expended on gases is calculated from the mean result of several other coals of similar constitution.—7. No evaporative trials of Osage coal or of bitumen have been made.—It appears that on an average, the first six varieties of coal expended in evaporating water from the boiler 85·35; and on the products of their combustion 14·65 per cent. of their whole heating power. Both the *sum* and the *number* of differences between the practical and the calculated evaporative powers, affected by the positive sign, are seen in the last column to be the same as those affected by the negative sign.

The relation between the *fixed* and *volatile* combustible matters of coals, is liable to considerable variation, according to the rate of distillation to which they are subjected. The more slowly this process is conducted, the higher (within certain limits) will be the proportion of fixed carbon.* The estimation of heating powers, therefore, from the quantity of fixed carbon which coals contain, if not wholly erroneous in principle, must be liable to considerable uncertainty in practice.

Many highly bituminous coals contain more than five per cent. of materials convertible into ammoniacal liquor by simple distillation without contact of air. This is proved on the largest scale in the manufacture of illuminating gas. That proportion, therefore, is not only unavailable for heating purposes, but it also abstracts from the really combustible materials of the fuel, all the heat, sensible and latent, which the vaporized ammoniacal products receive during combustion.

The proper *water of combustion*, namely, that derived from the *hydrogen in excess*, and oxygen of the atmosphere, must in every instance where heat is applied to evaporate water above the boiling point, as in all ordinary steam boilers, be likewise incapable of giving up its latent, as well as much of its sensible heat.

The average specific gravity of the six varieties of bituminous coals assayed is 1·31,—that of water at 60° being unity. Admitting the hydrogen in its solid state to have a density of only 1·25, it must in passing into the state, first of gaseous hydrogen, and then into that of watery vapor, (still having the same bulk as the hydrogen,) undergo an enlargement to 2117 times its original bulk. This volume is further increased according to the usual law of gaseous expansion, by whatever heat above the boiling point is left in the vapor, when it passes away from the surface to be heated. In a well constructed evaporative apparatus producing steam of six pounds pressure, in which the circuit traversed by the gases after passing the grate, and before reaching the chimney, was one hundred and twenty one feet, the temperature was generally about 100° above the boiling point; and the watery vapor, being of course surcharged with heat, possessed 2431 times the bulk which it had in the solid state and at 60° of temperature.

By the experiments of Dulong, (Comptes Rendus, tom. 7,)† one gramme of pure carbon developes, in burning, heat enough to raise the temperature of 7170 grammes of water, 1° centigrade, or 12906 grammes 1° Fahr. This latter number, is, therefore, used as a co-efficient, by which to multiply the numbers in the 12th column of the preceding table to obtain those of the 15th. By the same authority, 1

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* See Proceedings of the Acad. of Nat. Sciences, Vol. II, pages 9, 10.

† See also Peclet, Traité de la Chaleur, Tom. I, p. 50.

gramme of *gaseous* hydrogen gives heat sufficient to raise 62,535 grammes of water 1° Fah.

The average *excess of hydrogen* for the six varieties of coal tried by evaporation, as deduced from columns 13 and 14 of the table, is 4·636 per cent. which, calculated after the manner of the European chemists, ought to possess an evaporative power of 2·814. This would raise the average of the 15th column from 10·700 to 13·514, as the calculated evaporative power of the unit of combustible matter, showing the calculated to be 26·3 per cent. higher than the experimental effect.

The data furnished by the preceding table afford the means of ascertaining the proportion of its carbon volatilized in the distillation of the *combustible matter* in each kind of coal.

The calculations prove that of its whole carbon constituent, the per centage volatilized was as follows—

Cambria County coal, ...	16·767
Midlothian, new shaft, ...	29·195
Newcastle, ...	15·967
Clover Hill, ...	16·847
Scotch Cannel, ...	24·169
Caseyville, Ky., Cannel, ...	22·452
And that the average was	20·883

The *identity* of results obtained in the averages of the 15th and 18th columns should seem to demonstrate that the heating power of bituminous coal is proportionate to the *carbon* which they severally contain.

3. *Musée Botanique de* M. BENJAMIN DELESSERT; *Notices sur les collections de Plantes et la Bibliothéque qui le composent; contenant en outre des documents sur les principaux herbiers d'Europe: par* A. LASEGUE. Paris: Fortin, Masson & Cie, 1845. 1 vol. 8vo, pp. 588.—Baron Delessert, the proprietor of one of the richest herbaria and most complete botanical libraries of the world, is worthily distinguished, not only for the enlightened zeal which has prompted the collection of these treasures, and the knowledge which appreciates them, but also for the liberal manner in which they are thrown open to the use of men of science generally. As our author (the curator of this museum since the death of Guillemin) remarks, "these collections, brought together for the use of all, are constantly open to all, and the galleries of M. Delessert serve as a centre of reunion for all the savans who choose to labor there; thus renewing in our days the example given, at the commencement of this century, by the celebrated Sir Joseph Banks." This interesting volume is occupied with an account of the orgin of

this botanical museum, a notice of the herbaria it now contains, an enumeration of the botanists and botanical collectors who have contributed to enrich it, with a geographical table, bringing together methodically the names of such botanists or collectors, and the localities from which their plants were derived. To this is added a brief history of all the larger herbaria of Europe, and a general account of the principal botanical travellers and collectors, from Belon and Tournefort down to our own days. The volume closes with a notice of the botanical library of M. Delessert, which is pronounced to be the most complete known collection of books upon any one branch of science. It were greatly to be wished, therefore, that the excellent proprietor would publish a complete detailed catalogue of this invaluable library, which, as a Bibliotheca Botanica, would supply a great desideratum. Although this work is restricted to the botanical museum, we must not forget to mention that M. Delessert also possesses an unrivalled cabinet of shells—embracing the collection of Dufresne, and especially that of Lamarck, which itself comprises 13,288 species, and at least 50,000 individuals. The conchylogical cabinet is, however, entirely distinct and separate from the botanical museum; which last, as Lasègue remarks, is always "l'objet d'une predilection toute particulière," on the part of its possessor.

In a short chapter on the statistics of vegetables, M. Lasègue has given some interesting details on the successive increase in the number of species preserved in herbaria or described in general works. Thus, in 1546 Lonicer indicated 879 species of plants. In the first edition of the Species Plantarum, published in the year 1753, Linnæus described 5,938 plants; which number, in his later works, is raised to 8,551 species. In 1807, Persoon enumerates 25,949 species. In 1824, Steudel enumerates 50,649; in 1841, he gives a catalogue of 78,000 phanerogamous plants, which, with the estimated number of the Cryptogamia, raises the amount to 91,000; and the number of species since made known, enabled our author to raise the sum to 95,000 in 1844. It is equally interesting to notice the progressive increase in the described species of particular families or genera. Thus, in 1773, Linnæus knew 14 species of Oak; Persoon in 1807 enumerated 82; we now know 196. The described species of Violet, at these three periods respectively, are - - - - - 19, 55, 172.

Of Potentilla, - - - - -	22, 54, 186.
Astragalus, - - - - -	33, 169, 515.
Oxalis, - - - - -	13, 102, 308.
Carex, - - - - -	29, 209, 439.
Senecio, - - - - -	26, 135, 684, etc.

Genera have increased with equal rapidity. In the earliest edition of the Genera Plantarum, 1737, Linnæus characterizes 1043 genera.

In 1778,	Reichard gives	1343	"
1789,	Jussieu "	1902	"
1807,	Persoon "	2308	"
1824,	Steudel "	3933	"
1830,	Bartling "	4872	"
1841,	Endlicher "	7286	"
1844,	Lasègue counts	7500	"

Those who are ignorant enough to look upon this multiplication of genera as a downright evil, should compare with this list the actual number of known species at these several epochs. Lasègue estimates that the mean number of phanerogamous species for each genus, was,

in the year 1753,	5·06
In 1807,	9·13
1844,	12·00

But we cannot further notice these statistics, nor the estimates respecting the probable total number of the vegetables of the globe; which recent writers generally agree to place as high as 250,000. The chapter on the preparation and conservation of herbaria, is too brief to be of much practical use. The attention of M. Delessert was in early youth directed to botany by the perusal of the well known letters of Rousseau, which, although written at least seventy years ago, have as yet by no means lost their interest. It was to the mother of Delessert that these charming letters were actually addressed. "*La Petite*," for whom these lessons were prepared, was his eldest sister,—afterwards Madame Gautier. "Votre idée," Rousseau writes to Madame Delessert, "d'amuser un peu la vivacite de votre fille et de l'exercer à l'attention sur des objets agreables et varies comme les plantes, me parait excellente; mais je n'aurais jamais osé vous la proposer de peur de faire le Monsieur Fosse. Puisqu'elle vient de vous, je l'approuve de tout mon cœur, et j'y concourrai de même."

A small herbarium, made by Rousseau for his young pupil, preserved with great care, forms an interesting part of Delessert's vast cabinet. Each specimen, neatly prepared, is attached to its sheet of paper, adorned with a red border, by means of little gilded bandelettes, and their names, in French and Latin, are inscribed beneath in the handwriting of Rousseau.

The nucleus of the general herbarium was formed by Delessert's eldest brother, Stephen, who, as early as the year 1788, began to assemble and arrange the plants he collected during his travels in France, Switzerland, Germany, &c., as well as in Great Britain and the United States. But in September, 1794, Stephen Delessert was attacked by yellow fever in New York, where he died at the age of 23 years. Benjamin Delessert, who had accompanied his brother in his travels through France, Switzerland and Great Britain, gathering for himself the interesting plants he met with, now united these different collections, which thus served as the basis of what is now one of the largest botanical cabinets of the world. The actual number of plants it now contains, is estimated by Lasègue at 86,000 species, represented by 250,000 specimens. But this is a much larger proportion of the known species of plants than we should suppose it possible for any single collection to possess. Many particulars of high interest to botanical readers, are embraced in the history of the different herbaria which have from time to time been added to this museum; such as those of Commerson, the naturalist of Bougainville's voyage round the world; of Billardière, the two Burmanns, the Japanese herbarium of Thunberg, that of Ventenat, of Palisot de Beauvois, and nearly all the leading botanists and scientific travellers of recent times.* The notices of other principal European herbaria, comprised in the second part of the volume, also abound in interest; though in respect to many of them the author's information is insufficient. A. Gr.

4. *De Candolle's Prodromus, Vol.* 9.—A year ago we had the pleasure to notice the 8th volume of this indispensable work, the first of the series under the editorship of Prof. Alphonse De Candolle. The ninth volume, now before us, was issued on the first of January last; and the forthcoming portions are in course of preparation under such favorable circumstances that we may now confidently look for the appearance of a volume a year, and for the full completion of this Species Plantarum, according to the natural system, at no very distant period. We have already mentioned the arrangements that are made to secure this desirable consummation, and by which the work becomes as it were a series of separate monographs, prepared by the most skillful hands, under the superintendence of a common editor. Every botanist is aware of the improvement of the successive volumes as they appeared from the unrivalled hands of the elder De Candolle; and a further improvement is manifest in the later portions, elaborated or revised by his son, especially in the introduction of characters drawn from æstivation, placentation, the structure of the ovule, and other points which have only quite recently been turned to special account by sys-

* We should not omit to mention an interesting little collection of plants, a *souvenir*, bequeathed by De Candolle in the following clause of his will: "Je prie mon fils de choisir dans mon herbier cents plantes que j'ai decrites le premier, et de les addresser de ma part à mon bon et ancien ami Benjamin Delessert, comme témoignage de mes sentiments pour lui et pour sa famille."

tematic botanists. A particular account of a volume which is or soon will be in the hands of every working botanist, cannot be necessary, and we have not time at present for special enumeration. The 9th volume commences with the *Loganiaceæ*, by Alph. De Candolle. The genus Cœlostytis, *Torr.* and *Gr.*, is correctly reduced to Spigelia. Under this order we have a tribe created for the long-vexed Gelsemium, which we suspect is not yet finally at rest. Next follows the *Gentianaceæ*, elaborated by Grisebach, whose recent monograph of that family, which forms the basis of the present arrangement, was duly noticed in this Journal. The order *Bignoniaceæ* is edited from the manuscripts of the elder De Candolle; as also are the orders *Sesameæ* and *Crytandraceæ*, which last has been reduced by Mr. Brown to Gesneriaceæ. The *Hydrophyllaceæ* are elaborated by Alph. De Candolle, in which, by attributing generic importance to the presence or absence of the appendages or nectariferous scales within the tube of the corolla, the number of the genera is perhaps too greatly increased. The *Polemoniaceæ* are admirably worked out by Bentham, who has reduced to sections of Gilia his Hugelia, Fenzlia, Linanthus, Dactylophyllum, Leptosiphon, Leptodactylon, and the Ipomopsis, Michx. The elaboration of the *Convolulaceæ* by Prof. Choisy, does not appear to give entire satisfaction to botanists. The term "*infelicissime intricatus*" is perhaps still applicable to the family; and the genera are probably unduly increased in number. Of the *Borragineæ*, printed from the elder De Candolle's manuscripts, with valuable notes and additions by the editor, we have the first three tribes, viz. *Cordieæ*, *Ehretieæ*, and *Heliotropeæ*. But for the true *Borrageæ* we must wait until the appearance of the tenth volume, which is already in press. A. Gr.

5. *De Candolle; Theorie elementaire de la Botanique; ou Exposition des principes de la Classification Naturelle et de l'art de décrire et d'etudier les Vegetaux;* par Aug. Pyr. De Candolle. Troisieme edition; publiée par M. Alph. De Candolle, d'apres les notes et les manuscrits de l'Auteur. Paris, 1844. pp. 468, 8vo.—We are glad to announce the publication of a new edition of the *Theorie Elementaire*, one of the earliest and most important of the lamented De Candolle's writings, and which has left the most durable impress upon botanical science. The second edition, published in the year 1819, has long been out of print; and the illustrious author had intended, we are told, to prepare a final edition as a sequel to his herculean undertakings in systematic botany, to perfect the expression of the theory after it should have been applied to the elucidation of all the known families of plants, and have been itself tested and corrected by the application. Finding, however, that life was too short for the accomplishment of these vast

plans, he began to arrange his materials for a third edition, upon the basis of the second, and finally bequeathed to one of his pupils, M. Guillemin, the right to complete and publish it. But the legatee and favorite pupil soon followed the testator to the grave, before he had even commenced the fulfilment of the task. Under these circumstances this duty devolved upon the author's son, the present Prof. De Candolle, who prescribed to himself the following rules in its execution, viz. to make no alterations whatever, except in the following cases: 1st, where the author himself had already made certain changes, or had stricken out certain passages in his interleaved copy devoted to this use: or 2d, where he had already published, in some subsequent work, opinions different from those given in the *Theorie*: or 3d, where any of the facts adduced have since been ascertained to be erroneous: or 4th, where further details were requisite to render any statement more intelligible. Now that this work, so valuable in itself, and so inseparably connected with the history of the science, has at length been rendered generally accessible, we trust it will find a place in every botanical library in this country. A. Gr.

6. *Fifty Eighth Annual Report of the Regents of the University of the State of New York.* Made to the Legislature, March 1, 1845. Albany: printed by E. Mack, Printer to the Senate. 1845. Senate Document No. 51. pp. 290, 8vo.—The Regents of the University of the State of New York, constitute a Board of nineteen, besides three ex-officio members, viz. the governor, lieut. governor, and secretary of state. The vacancies by death or resignation are filled by the Legislature. This Board has the *governmental* management of the interests of education in the colleges and academies of the state. The regents require all those literary institutions, which receive *pecuniary* patronage from the state, to make an annual report on all the important matters of their arrangements, finances, text books, number of students, teachers or faculty, value of apparatus, volumes of library, amount of authors studied and time employed in doing it, ages of students reported in the academies, and their record of temperature and winds and weather, as well as the quantity of rain and snow, &c. In this way the regents hold all these institutions "subject to their visitation," and have the right to a direct examination of them by a committee of their number. The regents give specific instructions, in respect to these reports, and require them to be made after a particular form. From these reports, the regents of the university derive their annual report to the Legislature, and thus present a luminous view of the condition of their literary institutions, and of the great and beneficent results they are the means of accomplishing. This board is made to sustain a very important and

interesting relation to these institutions and to the great object of learning and education, and to the people who enjoy the benefits. They speak in this manner to the whole people every year, and their report is the index of the healthful action of these institutions upon the public mind.

Such an annual report must abound in statistics, and must be examined to be fully comprehended. It is widely spread over the state, and the regents are understood to be liberal in sending it to other states. We give the following abstracts.

Seven colleges and medical schools, and one hundred and forty six academies made their annual reports to the regents.

Number of students in the colleges, . . .	675
" " in the medical schools, . .	858
Increase of students in the former in the last four years,	22
" " in the latter " " "	253

The colleges and medical schools received from the state during the last year, $20,500.

The fostering care of the state has been shown in the last year in substantial pecuniary aid. It was merited, and will prove a public benefit.

To the several academies the state distributes, through the regents, annually, the sum of $40,000, being one portion of the literature fund. This sum is equally divided among the academies of the eight senatorial districts, in the proportion of the number of students engaged in *classical* studies or in the higher branches of English education. As the first district has only five academies, and claimed a part of the fund for only 765 pupils, and the fourth district has twenty six academies and claimed for 1914 pupils, and the eighth district has twenty two academies and claimed for 1876 attendants, it is obvious that this mode of distributing this fund is exceedingly unequal, and does not comport with the benevolent and republican principles of the plan in general. It needs only a thought to force the conviction that the division can be made *republican* by being made *equal* over the state. It may be expected from the generous policy of this noble state, that this inequality will not be suffered to continue another year.

Whole number of students in the academies in the year,	22,782
Distribution of literature fund allowed for . . .	12,257
Of this number, were of females, about . . .	5,700

The heart rejoices over this fact, that nearly one half of all those, who were pursuing classical or higher English studies, were females, the *daughters* of the rich and the poor, proposing to exert a more powerful and kindly influence on our citizens.

The amount of capital invested in the lots and buildings, libraries, apparatus, &c., of the academies was, for the last year, $1,338,088.

The tuition fees amounted to . . .	$188,583
The salaries of teachers to . . .	$192,252

Another fact shows the wisdom of the policy of the regents in advancing the interests of the academies. If an academy raise $250 or less from means not academic, for the purchase of library and apparatus, the regents give to that academy an equal sum. Thus the regents have distributed in past years, $27,800 for this object, and the academies have obtained books and apparatus amounting to more than $55,000, not a small portion of which is now in use and enhancing the worth of their instruction. The value of the apparatus in

Rutgers Female Institute is - - - - -	$1,779
Amenia Seminary, - - - - -	1,007
Albany Academy, - - - - -	1,532
Albany Female Academy, - - - -	1,936
Albany Female Seminary, - - - -	860
Troy Female Seminary, - - - -	1,697
Black River L. and R. Institute, - - -	1,651
Oneida Conference Seminary, - - -	1,272
Rochester Collegiate Institute, - - -	1,361

In many others it is several hundred dollars. We have not space to give the value of the libraries.

The report shows in a conclusive manner the vast importance of the academies. There must be a higher grade of education than even *improved* common schools can furnish. This is demanded by the exigencies of the country. This is adequate reason. The numerous and profitable applications of a higher education in the diversified pursuits of American enterprise, demand it. A comparatively small proportion of the students in the academies obtain a collegiate education, or only one thirty-fourth of the whole number, and not one twentieth of those in the higher English branches and classical studies. The academies benefit the middle and poorer classes more than the rich. The children of the rich enjoy the higher advantages in *some* way ; but the academies enable the poor to enjoy the same at moderate expense through the energy of the minds that long for knowledge. The academies keep down and prevent aristocracy in knowledge, and their destruction would at once enlarge the influence of aristocracy in wealth and knowledge. By much sacrifice many young men of slender means, or in destitution of property, have raised and are raising themselves to a more influential and important place among our citizens. The academies thus effect what the common schools cannot. Good policy requires, the high interests of the people require,—that the fostering care of the state should be more fully extended to the academies, and the appropriation of money to them be increased.

The academies, too, are the great source of teachers of common schools. The supply for a great normal school will be scarcely perceived among two millions of inhabitants. The academies must send forth ten to its one. A famine of knowledge would follow the abandonment of the academies. There can be no doubt that the *prime movers* of the mind of this great state will continue and extend the intellectual machinery which they have put in such successful operation and which has already produced such beneficial results.

The *meteorological* part of the report demands more than the passing notice now to be given. *Thirty nine* academies in all the sections of the state, have reported their observations on the temperature and winds and weather, and most of them the quantity of water fallen. Four academies have given their regular observations on the barometer, viz.—Millville Academy in Orleans county, the New York Institution for the Deaf and Dumb, North Salem Academy in Westchester county, and Rochester Collegiate Institute in the county of Monroe, two in the southern and two in the northern part of the state. The temperature is required to be taken in the coldest part of the day, just before sunrise, in the hottest part of the day, and about an hour after sunset. The daily mean is to be taken, and the mean of each half month, and of the whole month, and then of the whole year, at each place. The prevailing winds and weather are to be taken for each half day, and the general direction of the weather, is to be given in a tabular result. From all these observations, the report contains a grand abstract of facts.

For example, the mean temperature of the state for 1844, is 46°·70 Fah.

" " " "	1825 to 1836,	47 ·55 "
" " " "	1836 to 1845,	45 ·92* "

Quantity of rain from 1825 to 1836 is 35·10† inches.

" " for 1844 is 32·44 "

The coldest days were between Jan. 25 and 31, inclusive.

The warmest day was, in some places, in June, and in others, in July, August, or September.

Wind from the N. W. occurs on more days than from any other quarter of the horizon. The course of the prevailing winds is given, p. 187, for the whole state, from the *west*, but Prof. Coffin has shown the

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* Mean temperature of state for last 19 years, 46°·72.

† Quantity of rain from 1835 to 1845, 34·25 inches.

Average for last 19 years, 33·93 "

course of prevailing wind to be from several degrees south of west. To come to any trustworthy results on this great point, the observations must be very accurate, and the direction of the wind, not on the surface, but in the *main body of the clouds*, must be observed. From local causes or other forces, the lower current often varies greatly, from the prevalent direction. Probably much more attention must be given to this particular than the regents have yet required. The prevailing wind, that is, the resultant of all the winds, may then be found at the south of the S. W. direction, and in the course of the great mountain chains from the Gulf of Mexico. The report also contains a great amount of observations on halos, storms, frost, time of flowering of plants, aurora borealis, coming of birds, time of harvesting wheat, rye, &c. and of ripening of various fruits, appearing of reptiles, insects, &c., which make a rich treat to the connoisseur in these subjects.

It closes with a catalogue of plants in the vicinity of Penn Yan, Yates County, which does no little credit to Dr. H. P. Sartwell, an accurate and ardent botanist.

"In concluding the present annual report, the regents recur with pleasure to the evidently flourishing condition of the colleges and academies subject to their visitation." So let it be in time to come.

7. *Report of Experiments on Gunpowder, made at Washington Arsenal, in* 1843 *and* 1844. By Capt. Alfred Mordecai of the Ordnance Department. Washington, 1845. 8vo, pp. 328. 4 plates. —This Report embodies the results of many thousands of accurate experiments made by Capt. Mordecai, under government authority, with instruments constructed in such a manner as to insure perfect accuracy. Having had the satisfaction of inspecting the instruments, and of hearing from Capt. Mordecai an account of the methods of experimenting, we can speak of them with the greater certainty. The force of gunpowder, since the time of Hutton and the French experimenters, has been calculated by means of the *balistic pendulum* and of a *gun pendulum*. The *gun* (in these experiments a twenty-four and a thirty-two pounder) is suspended in an iron frame, hung on knife edges of hardened steel, like a balance beam, the whole supported (a load of 10,500 lbs.) on massive stone pillars. The recoil is measured on a limb of brass, having a curve, of which the frame work and the gun are the radius, and graduated to read to seconds by means of a vernier which is moved by the recoil, and retained at the point of greatest vibration by a slight spring. When the gun is adjusted and at rest, its axis is a horizontal line, and the vernier stands at zero on the scale.

At a distance of only fifty-five feet, (between the centres,) is inserted the *pendulum block* for receiving the shot and measuring its velocity.

This *pendulum* is a counterpart to the gun, as regards its mode of suspension and motion, which is also measured in like manner on a graduated arc. This "*block*" as it is called, resembles a mortar or wide howitzer, with a bore of four and a half feet deep and fifteen inches calibre, and filled with leathern bags of sand, and a bedding of lead. This block, the frame and counterpoise weights, weighed 9,358 lbs., and was suspended so as to hang when at rest, with its axis perfectly in one and the same line as the axis of the gun. When prepared for use the aperture of the pendulum block was covered by a sheet of lead, which served to make the deviation of the ball from a right line, by the hole which was pierced in it. This deviation was found to be very slight.

It seems, to a person unaccustomed to such experiments, a rather daring attempt to fire a thirty-two pound shot, at the distance of only fifty feet into the mouth of another gun. But that velocity which left unrestrained, would serve to carry the shot for miles, is in this apparatus restrained within the range of a few feet, and imparts only a moderate motion on the great mass of matter on which it impinges, which can be wholly and accurately estimated. Capt. Mordecai remarks that "an observer placed in such a position as to see the face of the block unobscured by the smoke of the gun, perceives at the moment of impact, a circle of *reddish white flame* surrounding the hole made by the ball." He supposes "that this flame may be produced by the combustion of minute particles of iron and lead ignited by friction." He further remarks, that "in firing a thirty-two pound ball into the pendulum block with a charge of eight pounds, the sand immediately before the ball was compressed into a solid mass, forming an imperfect sandstone sufficiently firm to bear handling. A specimen is still preserved in that state after a lapse of more than eighteen months." This sand when examined, was found quite free from any calcareous cement. An apparatus of quite similar structure, on a proportionate scale, was used for muskets. In these experiments powder from a great number of manufactories, and of great variety of composition, grain and finish, were tested. The elements for calculating the strength of gunpowder, obtained by these experiments, were resolved by the formulæ of Hutton and those which more recently have been employed by the French at Metz. This portion of the labor is performed with the accuracy and skill, which characterize all the highly educated officers from West Point Academy. Capt. Mordecai concludes from the results of his experiments, that the only reliable mode of proving the strength of gunpowder is to test it, with service charges, in the arms for which it is designed; for which purpose the balistic pendulums are perfectly adapted.

In the twenty-four pounder gun, new cannon powder should give, with a charge of one-fourth the weight of the ball, an initial velocity of not less than sixteen hundred feet, to a ball of medium size and windage.

The initial velocity of the musket ball, of 0·05 in windage, with a charge of one hundred and twenty grains, should be

With new musket powder not less than	1,500 feet.
" " rifle " " "	1,600 "
" fine sporting " " "	1,800 "

The common eprouvettes are of no value as instruments for determining the relative force of different kinds of gunpowder.

The proportion used in making our best powder, 76.14.10, and the English 75.15.10, appear to be favorable to the strength of powder. The best mode of manufacture is in what is called the cylinder mills under heavy rollers, and this process alone is considered capable of making good sporting powder. The English have employed this process for fifty years, but the French still use the old method, by stamping or pounding. The "*gravimetric density*" should not be less than 850 nor more than 920. The charge for cannon for all ordinary purposes should be one-fourth. No purpose, even breaching a battery, requires more than one-third the weight of the ball. For small arms the following charges are proposed: for the percussion musket, 110 grains; the percussion rifle, 75 grains; the percussion pistol, 30 grains of rifle powder. It is proposed that musket and rifle balls should be made by compression, instead of casting as at present. The body of the volume is occupied by extended tables, containing the full detail of the experiments, properly classified.

8. *Rural Economy in its relations with Chemistry, Physics, and Meteorology; or Chemistry applied to Agriculture;* by J. B. Boussingault. Translated, with an introduction and notes, by George Law, Agriculturist. New York, D. Appleton & Co., 200 Broadway. 12mo, pp. 507.—Boussingault's labors have been known heretofore, to English readers, chiefly, if not only, by the frequent reference made to them by the popular chemical and agricultural writers of the day. They have been a mine of facts to the builders of theories, and have furnished some inferences which probably the author never dreamt of. No man has made more, or more extensive practical experiments in agriculture than Boussingault, and no results are more reliable than his. It is with much pleasure that we find before us a translation of his collected papers, a series much needed for the benefit of agricultural readers. The two stout volumes of the original French are here embodied into one, partly by the use of a smaller type and closer and larger page,

and somewhat, also, by the omission of certain chemical matters not deemed by the translator important to the American reader.

The first part of this work treats in succession of the physical and chemical phenomena of vegetation, of the composition of vegetables and their immediate principles, of fermentation, and of soils. The second comprises a summary of all that has yet been done on the subject of manures, organic and mineral: a discussion of the subject of rotations; general views of the maintenance and economy of live stock; finally, some considerations on meteorology and climate, and on the relations between organized beings and the atmosphere. Now that this valuable work is within the reach of all classes of readers and done into good English, we have no doubt that it will make its way to every remote hamlet in the land.

9. *Proceedings of the Academy of Natural Sciences of Philadelphia*, for March and April, 1844.—Contain descriptions of the following species of American Coleoptera. By F. E. Melsheimer. p. 26–43.

Hydradephaga: Leionotus compar, *Harris;* Thermonectus irroratus, T. nimbatus; Hydaticus meridionalis; Agabus terminalis, A. arctus, A. punctatus; Laccophilus rufus; Hydroporus dichrous, H. striatopunctatus, H. luridipennis, H. limbalis, H. dubius; Hygrotus pustulatus; Cyclous opacus, C. labratus.

BRACHYELYTRA.

Aleocharidæ.—Palagia erythroptera, F. globosa; Homalota flaveola, H. polita, H. modesta; Oligota pedicularis (Aleochara pedicularis, *M. Cat.*); Gyrophæna rufa (Aleochara rufa, *M. Cat.*); G. flavicernis, G. lateralis. Tachyporidæ: Tachyporus punctulatus; Tachinus discoideus, T. limbatus; Boletrobius dimidiatus; B. venustus (Tachinus trimaculatus, *Say*), B. binotatus.

Staphylinidæ.—Xantholinus palliatus, X. obsidianus, X. sanguinolentus; Staphylinus violaceus; Belonuchus pallipes; Philonthus Harrisii (Staphylinus picipes, *Harris*), P. lætulus (S. lætulus, *Say*), P. pulchellus, P. nanus, P. brevis (S. dimidiatus, *Say*), P. cinctatus, P. raficornis, P. niger, P. fusiformis. Oxyporidæ: Quedius bardus, Q. terminatus; Oxyporus dimidiatus, O. brevis, O. fasciatus. Pæderidæ: Lathrobium longiusculum; Stilicus angularis. Stenidæ: Stenus erythropus. Oxytelidæ: Oxytelus basalis, O. pygmæus, O. parvulus. Piestidæ: Prognatha Americana. Omaliidæ: Oloprum emarginatum, Erichron; Anthobium dimidiatum.

Descriptions of New North American Coleoptera. By Rev. D. Ziegler, of York, Pa. The following species are described, pp. 43—47.

Oxyprus pulcher; Diacanthus splendens; Scyrtes suturalis; Hydnocera? longicollis; Spercheus tesselatus; Hydrophilus ovalis; Coprobius obtusidens; Pandarus(?) brunneus; Cistela marginata, C. erythroptera; Pedilus nigricans, P. hæmorrhoidalis, P. ruficollis, P. marginicollis; Monohammus tomentosus; Œdionychis (?) hispida.

Descriptions of New Species of North American Coleoptera. By JOHN L. DE CONTE. The following species are described, pp. 48—53.

Galerita dubia; Plochionus vittatus; Aptinus Americanus, *Dej. Cat.;* Bachinus strenuus, B. Le Contei, *Dej. Cat.*, B. cyanopterus, *Dej. MS.*, B. viridis, B. neglectus, B. tenuicollis, B. patruelis, *Dej. Cat.;* Clivina impressifrons, C. convexus; Rembus striatopunctus, R. assimilis; Chlænius congener, C. patruelis; Badister terminalis, B. testaceus, B. micans; Oodes picipes, Pristonychus Americanus; Calathus distinguendus; Anchomenus Le Contei.

Descriptions of Insects, by S. S. HALDEMAN, pp. 53—55.—Leucospis integra; Hedychrum janus; Typhlopone pallipes; Eumenes substricta; Scaphinotus flammeus; Scarites substriatus, S. distinctus, S. subterraneus, *Fabr.;* Agrion venerinotata; Termes frontalis.

IBID., for May and June, 1844.

Descriptions of New Species of African Reptiles from Liberia, p. 58. Euprepis Blandingii; Ixalus concolor; Leptophis gracilis and L. Kirtlandii.

IBID., for September and October, 1844.

Description of some New Species of Fossil Organic Remains from the Eocene of South Carolina; by EDMUND RAVENEL, M. D., of Charleston, S. C.—The species described are Pecten Mortoni, P. Holbrookii; Terebratula canipes; Scutella pileus-sinensis.

Descriptions of New Species of Coleoptera of the United States; by F. E. MELSHEMIER, M. D.—The following species are described, pp. 98—117.

HETEROCERIDÆ: Heterocerus ventralis, H. undatus, H. brunneus. PARNIDÆ: Elmis vittatus; Macronychus lateralis. HELOPHORIDÆ: Hydrochus gibbosus, H. rufipes. HYDROPHILIDÆ: Berosus auritus; Laccobius punctatus; Philhydrus limbalis, P. fimbriatus, P. ochraceus. SPHÆRIDIIDÆ: Cercyon maculatum, C. nanum, C. mundum, C. minusculum. AGATHIDIIDÆ: Phalacrus politus, P. apicialis, P. nitidus; Leiodes alternata, L. discolor; Agathidium piceum, A. egiguum. SCAPHIDIIDÆ: Scaphidium piceum; Scaphisoma terminatum. SILPHIDÆ: Pettis quadrilineata, P. marginata. NITIDULIDÆ: Cercus punctulatus, C. pusillus; Carpophilus antiquus, C. minutus, C. bimaculatus; Nitidula uniguttata, N. rufida; Osmosita badia; O. castanea; Pallodes obsoletus. ENGIDÆ: Cryptarcha picta; Nitidula (Ips.) fasciata; I. geminatus; Rhyzophagus (?) parallelus, R. erythropterus; Trogosita castanea, T. corticalis, T. limbalis, T. dubia, T. nana, T. bimaculata; Bitoma undulata; Bothrideres exaratus; Monotoma fulvipes; Synchita fuliginosa; Cicones marginalis; Xylotrogus brevicornis, X. parallelipipedus; Lyctus striatus, L. axillaris; Læmophlœus fasciatus; Tebratoma obsoleta. Mycetophagidæ: Mycetophagus bimaculatus, M. bipustulatus; Atomaria pubescens, A. crenata, Antherophagus ochraceus; Cryptophagus maculatus; Corticaria pulicarius. Dermestidæ: Trogoderma (?) tarsale; Anthrenus destructor, A. castaneæ, A. thoracicus. Byrrhidæ: Syncalypta hispidus; Byrrhus trivittatus, B. undatus, B. glabellus; Simplocaria strigosa.

Descriptions of New Species of Reptiles from Africa; by E. Hallowell, M. D.—The species described are the following, p. 118. Coluber lævis; Dipsas carinatus; Trionyx Mortoni.

Ibid., for November and December, 1844.—No. 6.

Descriptions of New Species of Coleoptera of the United States; by F. E. Melsheimer, M. D., pp. 134—160; continued from p. 118.—The following are the names of the species described.

Lamellicornia: Onthophagus castaneus, O. niger, O. rhinoceros, O. protensus; Aphodius badipes, A. pensvallensis, A. truncatus, A. copronymus, A. stercorosus, A. rusicola, A. aterrimus, A. imbricatus, A. maculipennis; Oxyomus gracilis, O. alternatus; Trox striatus, T. variolatus; Bolbocerus cornigerus; Bothynus castaneus; Ancylonycha pruinosa, A. rugosa; Anomala dichroa, A. undulata, A. pinicola; Hoplia monticola, H. tristis, H. helvola. Buprestidæ: Dicerca dubia, D. aurichalcea, D. parumpunctata, D. chrysea, D. indistincta, D. meliter, D. impressifrons, D. ferrea, D. consobrina, D. gracilipes; Buprestis inconstans; Melanophila æreola, M. metallica; Chrysobothris calcarata, C. punctata, C. strangulata, C. viridiceps, C. rugosiceps; Anthaxia gracilis, A. scoriacea. Eucnemideæ: M. pectinicornis; Lissomus nitidus; Hylocharus (?) bicolor; Dirhagus badius; D. rufipes. Elateridæ: Ctenonychus sphenoidalis, C. ochraceipennis, C. testaceus, C. depressus, C. parumpunctatus; Melanotus ignobilis, M. glandicolor, M. paradoxus; Athoiis vagrans, A. æqualis, A. melanophthalmus, A. strigatus, A. cavifrons, A. oblongicollis, A. hypoleucus, A. æreolus, A. æreus, A. procericollis, A. arcticollis, A. trivittatus, A. tarsalis; Limonius posticus, L. metallescens; Cardiophorus amictus; Ectinus granulosus; Elater humeralis, E. impolitus, E. hepaticus.

Descriptions of New Species of African Reptiles; by E. Hallowell, M. D.—The species described are, Coluber Phillipsii; Bufo cinereus; Plestiodon Harlani; Dipsas Blandingii, Tropidolepis Africanus, Leptophis viridis, Coluber ater.

Descriptions of eight new Fossil Shells of the United States; by T. A. Conrad.—*Miocene species;* Crepidula cymbiformis. *Eocene* *species ;* Cardita densata; Cytherea subimpressa, C. liciata, C. eversa, C. pyga; Pecten elixatus. *Carboniferous species ;* Bellerophon scissile.

IBID., for March and April, 1845.

Description of a New Vulture from Vera Cruz ; by JOHN CASSIN. p. 212.—The Cathartes Burrovianus. "C. capite nudo, lævi, naribus magnis, ovatis, corpore omnino nigro, viridi-cærulescente subnitido, subtus pallidiore; plumis extendentibus sursum super posteriore cervicis, parvo spatio in pectore nudo. Alis longis, remigibus et rectricibus nigris, scapis primarum albis et conspicuis, tertia prima longissima." Long. tot. (exuvii) 22 unc., rostri 2½, alæ 18, caudæ 8½.

Descriptions of New Coleoptera of the United States ; by F. E. MELSHEIMER; continued from p. 160—pp. 213. The following species.—Elater fuscatus, E. testaceipes, E. ursulus; Cryptohypnus obliquatulus, C. guttatulus; Oophorus crassicollis; Corymbites atropurpureus, C. hirticollis, C. interstitialis; Diacanthus (?) signaticollis; Pristilophus (?) sordidus, P. femoralis; Agriotes truncatus, A. striatulus, A. pubescens; Dolopius isabellinus, D. oblongicollis; Adrastus testaceus; Campylus flavinasus, C. (?) bivittatus. RHIPICERIDÆ: Sandalus rubidus, S. brevicollis. CEBRIONIDÆ: Atopa ornata, A. bicolor, A. fusca. CYPHONIDÆ: Nycteus (?) thoracicus; Eubria (?) nervosa; Scyrtes solstitialis.

10. *The Chemistry of Vegetable and Animal Physiology :* by Dr. G. J. MULDER, Professor of Chemistry in the University of Utrecht. *Translated from the Dutch*, by P. F. H. FROMBERG, First Assistant in the Laboratory of the Agricultural Chemistry Association of Scotland. *With an Introduction and Notes*, by Prof. JAMES F. W. JOHNSTON, F. R. SS. L. & E. First American Edition, with Notes, by B. SILLIMAN, Jr. Part I, 12mo, pp. 176. New York and London, Wiley & Putnam, 1845.—We have before noticed the appearance of a part of Mülder's valuable treatise on the Chemistry of Physiology in its American dress. The first part complete has now been before the public for several weeks, embracing the following subjects in *five* chapters.

Chap. I.—Chemical and Organic Forces. Chap. II.—Inorganic, Organic, and Organized Bodies: Plants and Animals. Chap. III.—The Atmosphere in its connection with Organic Nature. Chap. IV.—Water considered in its Connection with Organic Nature. Chap. V.—Relation of the Soil to Organic Nature.

From the somewhat speculative turn given by the author to the first chapter, on Chemical and Organic Forces, it was feared by some of his readers, that the work would possess a less practical and useful character than was to be hoped for, from the renowned professor of chemistry in the University of Utrecht. This groundless apprehension is abundantly set aside by the chapters which immediately follow. As it is our intention to present an analysis of Mülder's views, at some length, in a future number of this Journal, we shall at present do no more than recommend it to the careful perusal of our readers, for it is a work not to be fully appreciated by a cursory reading.

11. *Life of* Godfrey William Von Leibnitz; on the basis of the German work of Dr. G. E. Guhbrauer. By John M. Mackie. 12mo, pp. 288. Boston, Gould, Kendall & Lincoln. 1845.—The biography of great and learned men, of those who have, by their labors in the common cause of sound knowledge, either opened new paths of investigation, or made more accessible those which before existed, is one of the most interesting and valuable departments of literature, and one peculiarly adapted to the advancement of science. Leibnitz was the author of much of that peculiar philosophy, which, adopted with certain variations by Kant and other Germans, has become universally known as *the* German philosophy. He was a man of great and varied attainments,—varied to an extent rarely reached by any but the German mind, and profound in all. His prolonged life of industrious application, gave him opportunities for going over almost an entire field of human knowledge, and wherever he went, his uncommon powers of invention and research enabled him to make original and important discoveries. He was a cotemporary of Newton; and, like the great English philosopher, he early fell upon new and invaluable methods in the higher mathematics. Without entering at all into the merits of the protracted personal controversy, which grew up between Newton and Leibnitz, regarding the *priority* of discovery of the method of fluxions,—the differential calculus,—we can say, that Leibnitz was undoubtedly *an original* discoverer, and the French philosophers have not hesitated to award him the palm of decided priority. All scientific Europe, for a quarter of a century, was embroiled by this celebrated controversy, which was actively kept up for years, after death had removed Leibnitz from the arena, which event no doubt, gave an undue advantage to the English competitor, aided, as he was, by the well-known report of the Committee of the Royal Society, to whom the affair was committed for adjudication, and who, singularly enough, concluded their labors without giving to their German member an opportunity of defending before them his claims.

Mr. Mackie has given a very impartial view of the history of this controversy, and also a well condensed summary of his peculiar philosophical tenets before alluded to. The memoir is well written, free from repitition, and consequently makes the *subject* the most prominent thing before the reader. We have read it with equal pleasure and profit, and have no doubt that it will meet with general approval. It is evidently not a translation from the German memoir, but rather an analysis and condensation, thrown into a connected and attractive form.

12. *Wiley & Putnam's Catalogue of Scientific Books. Part I, Medical Science.*—These enterprising publishers have made it comparatively easy to us, in this country, to become acquainted with the standard works of European authors, in all departments, by the facilities which their establishment affords to obtain those which fall in the way of each reader. This service is peculiarly useful to those whose isolated position in small towns in the interior of the country cuts them off from other sources of information.

The medical practitioner will find the first part of this well-digested catalogue, of great service, in enabling him to keep up with the rapid advances of his profession. We will, also, in this connection, notice

13. *Library of Choice Reading*, in course of publication by the same publishers. This series is designed to supply a better material for the taste which the public have acquired for "*cheap literature*" and science, than the vapid trash which has, during the last few years, fallen stillborn from the press in such quantities as to have become a nuisance and seriously to impede the progress of better books. We have seen already *ten* parts of this series, comprising a number of well known works of established reputation—"books which are books," viz. Eōthen; Mary Schweidler, the Amber-witch; Undine; Imagination and Fancy, by Leigh Hunt; The Diary of Lady Willoughby; Hazlitt's Table Talk, parts 1 and 2; Headlong Hall and Nightmare Abbey; The French in Algiers, by Lady Duff Gordon; Ancient Moral Tales, from the Gesta Romanorum.

14. *Handwörterbuch der Topographischen Mineralogie* von Gustav Leonhard, Doctor der Philosophie, &c. 1 vol. 12mo, 596 pp. Heidelberg, Akademische Verlags-Handlung von J. C. B. Monn. 1843.—While the science of mineralogy appears to be rather on the wane in England and France, Germany continues to prosecute it with unabated zeal, and every year witnesses the announcement of new works and new discoveries. For three-fourths of the new species added to the science within a few years past, we are indebted to Germany and Northern Europe. To the same countries, also, do we look for the greater part of the late improvements in analytical chemistry.

The work, whose title is above given, is one of the number, relating to mineralogy, that have appeared in Germany within the last two years. As the title indicates, it is occupied solely with topographical mineralogy, or in other words it is a book of mineral localities, containing the mineral species in alphabetical order, with their various localities throughout the world. From the correct orthography of our own names, we may judge of the accuracy and care with which its pages have been prepared. To mineralogists who may travel abroad, and to those who have cabinets or make exchanges, such a work is obviously highly important. The deciphering of illegible labels is a common trouble with the mineralogist not well versed in the languages of Europe; here Leonhard supplies a ready aid, besides giving some idea of the geographical position of the places. It also enables one, through the associated minerals, often to ascertain the locality when unknown; and it supplies the means of comparing our own localities, and the associated minerals with those of the same species abroad. As a book of reference, therefore, Leonhard's work will be found highly convenient, and the more so for its concise, systematic, tabular mode of arrangement. In carrying out his plan the localities are first given for Europe, mentioning in order those of the separate countries or departments;—as for example, under *Pyrites*, severally, Spain, France, England, Scotland, Ireland, Netherlands, Switzerland, Denmark, Sweden, Norway, Prussia, Hanover, Hartz, Saxony, Hesse Cassel, Hesse Darmstadt, Nassau, Baden, Wurtemberg, Baiern, Austria, Italy, Greece, Russia, Poland. Then the continents, Asia, Australia, Africa, and America, including under the latter the subdivisions, Greenland, British North America, United States, Mexico, Peru, Chili, Brazil, and Uraguay.—The work closes by a second table containing all the places mentioned as localities, arranged in alphabetical order, under the different countries to which they belong.

15. *The Botanical Text Book, for Colleges, Schools, and Private Students;* comprising, Part I. An introduction to Structural and Physiological Botany. Part II. The principles of Systematic Botany, with an account of the chief natural families of the Vegetable Kingdom, and notices of the principal useful plants. 2d Edition, with more than a thousand wood cuts. By Asa Gray, M. D., Fisher Professor of Natural History in Harvard University. 509 pp. 8vo. Wiley & Putnam, New York, 1845.—This second edition of a work that has already gained a high reputation, is very much enlarged and improved, both in subject matter and illustrations. The author states in his preface, that the first part on structural and physiological botany, has been mostly rewritten and amplified to nearly twice its former extent; and the numerous figures added have given increased simplicity and clearness to this part of the subject, while at the same time it is rendered more complete. The chapters upon the principles of classification and the natural system have also been recast and somewhat enlarged; while those illustrative of the natural orders have been condensed, without,

however, the omission of any thing of proper botanical interest. The whole number of pages has been increased in this edition, about one quarter, and the wood cuts, which are all remarkably clear and well printed, have been more than doubled in number. The volume is a beautiful one in its typography and general appearance, and of the highest order of scientific merit. While sufficiently complete for the advanced student in the science, it is at the same time as simple and perspicuous as can be required by the beginner.

16. *A Class Book of Botany*, designed for Colleges, Academies and other Seminaries. In two Parts: Part I. The Elements of Botanical Science. Part II. The Natural Orders, illustrated by a Flora of the northern Uninted States, particularly New England and New York. By ALPHONSO WOOD, A. M., Associate Principal in Kimball Union Academy. Boston: Crocker & Brewster. Claremont, N. H.: Simeon Ide. 1845.—This work is constructed on the natural system, and has been a great desideratum for several years. Its *Elements of Botanical Science* contain a faithful, clear, and definite view of the principles taught by De Candolle, Lindley, Gray, Torrey, &c., the Classes, Orders and Genera, are all founded on the same authorities, and its descriptions of specimens, comprising all the plants of New England and New York especially, except the lower orders of Cryptogamia, are according to the natural method. The artificial system of Linnæus, by means of a few plain and ingenious tables, is employed only to lead the learner to the genus or the natural order where the plant is found and described. This work makes the study of plants interesting and fascinating, and must in our country supersede all the common works on the Linnæan methods. Teachers of academies, schools, &c., will find it a noble work for their use in the study of plants. Y.

17. *Owen's Illustrated Catalogue.*—A quarto volume has just appeared, being a Descriptive and Illustrated Catalogue of the fossil organic remains of Mammalia and Aves contained in the Museum of the Royal College of Surgeons in England. Edited by Prof. OWEN. pp. 390, with ten lithographs.—Plate 1 is a restored figure of the gigantic extinct Armadillo (Glyptodon) of South America—it is very beautiful; all the tesselated osseous carapace remains; even the case which covered the tail and the casque that protected the skull; there is a fine plate of the cranium of the same annimal. This work, like all Prof. Owen's productions, is very excellent—not a dry catalogue, but full of information of the highest palæontological interest.*

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* Letter from London to the Senior Editor.

18. *Vestiges of the Natural History of Creation.*—In Vol. XLVIII, p. 395 of this Journal, we have mentioned this new work, with its novel and startling views and opinions. Upon it our respected London correspondent remarks :—"It has made a great sensation ; chiefly, I believe, because the author cannot be detected,* and that two hundred copies were gratuitously delivered to the leading scientific and literary men. It is evidently the work of a very clever man, who has read much and speculated more ; and who is not an original observer. It embraces all the natural sciences, and abounds in the most extraordinary speculations, most of them based on insufficient data, or on mistaken facts. His object is to prove that creation has proceeded according to a law impressed by the Creator on matter, by which organic forms arise from inorganic atoms, and that the simplest and most primitive type, under a law to which that of like production is subordinate, gave birth to the next type above it ; that this again produced the next higher, and so on to the very highest, the stage of advance being, in all cases, very small, namely from one species to another. In support of this theory of progressive development, geology and physiology are made to succumb to the views of the author. I have no time," remarks the writer, "for farther comment, but I think the book false in religion and philosophy, and all its errors are swallowed by the upper classes, to whom every thing boldly asserted and in captivating style is gospel."

19. Dr. G. A. MANTELL *on the Geological Structure of the country seen from Leith Hill in the county of Surrey ;*—(from Brayley's Topographical History of Surrey.)—A very beautiful thin quarto of only 19 pages, adorned by three exquisite pictures of landscape views, and five wood cuts of the structure of the country, is received from the author almost at the moment of closing our number. This little geological tract is a contribution from Dr. Mantell to Brayley's Topographical History of Surrey, a splendid work now going through the press in England ; another addition to works, (of which England possesses many valuable ones,) on the local history of counties and districts in that country. The present work illustrates : I. The Natural State ; II. The History and Antiquities ; III. The Social Economy and present condition of the county of Surrey, a region rich in historical, social, and geological interest. The formation of chalk and the Wealden having been so often and so ably illustrated by Dr. Mantell, it is almost superfluous to add, that this tract corresponds with the well known character of his mind for dignity, discrimination, and for the living interest which is diffused over all his productions.

* We have heard it attributed to a celebrated London zoologist, whose name we forbear to cite, as we are not sure of the fact.—EDS.

MISCELLANIES.

FOREIGN AND DOMESTIC.

1. *Abstracts of the Researches of European Chemists;* prepared for this Journal by J. LAWRENCE SMITH, M. D. of Charleston, S. C.

Silicic Ether, by M. EBELMAN, (Comp. Rend. Aug. 1844, p. 399.)—If absolute alcohol be added with precaution to chloride of silicon, a violent action takes place, with an abundant escape of hydrochloric acid gas, and a considerable diminution of temperature; when the alcohol added exceeds by a little the quantity of chloride used, the escape of gas ceases, and the temperature of the liquid rises. If the mixture be distilled, there passes over first a small quantity of hydrochloric ether, and then the greater part of the liquid distills between 320° and 338° Fah.; this is laid aside, and the distillation terminated at 572° Fah. There remains in the retort a mere trace of silica.

The first product, when rectified, has a fixed point of ebullition between 323° and 325° Fah., a penetrating ethereal odor, strong peppery taste, and a density of 0·932; it is insoluble in water, but by long contact with it is slowly decomposed, perfectly neutral in its reaction, dissolves in alcohol and ether in all proportions; the alcoholic solution is decomposed by alkalies, with a deposition of gelatinous silica; a few drops thrown into a red hot platinum crucible burn with a white flame, depositing silica. Upon analysis it proves to be a silicate of the oxide of ethyle, having for its formula—

$SiO^3\,3C^4H^5O$, (with Berzelius's equivalent for silica, 22·1.)
or $SiO\,3C^4H^5O$, (with Dumas's equivalent for silica, 7·3.)

By fractional distillation of the liquid that passed over between 338° and 572° Fah. and analyzing, it is found that the proportion of carbon and hydrogen remains unchanged, the silica constantly increasing. That portion of liquid distilled at about 572° Fah. is colorless, possesses a feeble odor, and is of a different taste from the first ether; its density is 1·035; the action of water and of the alkalies is the same as upon the other. Its formula is, $(SiO)^2\,C^4H^5O$.

From this it would appear that silicic acid has at least two ethers—the first fact of the kind connected with the history of the ethers, and which corresponds to the numerous silicates of different degrees of saturation found in the mineral kingdom. The following is the manner in which the alcohol and chloride of silicon react to form the two ethers.

$SiCl + C^4H^6O^2 = HCl + SiO\,C^4H^5O$, first ether.

$(SiCl)^2 + 2(C^4H^6O^2) = C^4H^5Cl + HCl + (SiO)^2\,C^4H^5O$, second ether.

Oxide of Phosphorus, by BERZELIUS, (Chem. Gazette, Aug. 1844, p. 301.)—When a large surface of phosphorus is exposed to the action of dry atmospheric air, it is slowly oxidized without forming any free phosphoric acid, being converted into a brown mass, which is the phosphate of the oxide of phosphorus decomposed by water, with a separation of the pure oxide. This is however more readily formed by pouring liquid sulphuret of phosphorus into a flask containing dry air, which must be occasionally renewed by means of a chloride of calcium tube; the inside of the flask soon becomes covered with a brown tenacious mass. At the expiration of a week the flask is to be filled with water, with which the mass mixes, forming a beautiful yellow milk; this is removed with a syphon to prevent any of the undecomposed sulphuret from mixing with it. The liquid being heated to 176° Fah. becomes clear with the deposition of a yellow hydrate of the oxide of phosphorus. It should be washed and dried in the air.

Phosphuret of Lime, (Compt. Rend. Aug. 1844, p. 313.)—This substance, sometimes called phosphuret of calcium, has been the subject of some recent investigations by M. Thenard, and he has found that the composition of it, whether made by passing the vapor of phosphorus over laminæ, or small lumps of incandescent lime, is the same—the surface containing no more phosphorus than the centre. The following is the nature of the chemical change that takes place: 10 equivalents of lime are decomposed, its oxygen combining with 2 equivalents of phosphorus, forming phosphoric acid, which combines with a portion of lime,—the calcium liberated combining with the rest of the phosphorus, which is 5 atoms, forming phosphuret of calcium,—so that the phosphuret of lime is a mixture of definite proportions of the phosphate of lime and phosphuret of calcium—$2PO^5\,4CaO+5PCa^2$.

The changes which take place when this substance is brought into contact with water are these:—the phosphuret of calcium and water by their mutual reaction produce the liquid phosphuretted hydrogen, (see abstracts, Am. Jour., Vol. XLVIII, Jan. 1845,) and lime, without the appearance of the hydrosulphite—$5PCa^2$ converted into $5PH^2+10CaO$. As the liquid phosphuretted hydrogen is very unstable, particularly in the presence of lime, it is transformed into the gaseous spon-inflammable phosphuretted hydrogen and the solid variety thus—$5PH^2=P^2H+3PH^3$; as the action continues to develope itself, the quantity of lime increases, the gas becomes less and less inflammable, and contains more and more hydrogen, because the solid phosphuretted hydrogen disappears under the influence of water and an alkali; and the liquid which at first contained but a little hypophosphite now becomes changed, and it can be collected upon filtering and evaporating.

If the phosphuret of lime be thrown into concentrated muriatic acid, the liquid phosphuretted hydrogen, which is at first formed is immediately decomposed into solid and gaseous non-spon-inflammable phosphuretted hydrogen. If the acid be diluted it is not so speedily decomposed, and the gas that comes over is spon-inflammable from the fact that it contains in suspension a small portion of the liquid phosphuretted hydrogen, which was shown to be the substance to which the gas owes its inflammability. Adding phosphuret of lime to dilute muriatic acid is the most convenient method of obtaining the spon-inflammable gas, from the fact of its readily dissolving the phosphate of lime contained in the mass.

Benzoic Acid and Hydruret of Benzoile, decomposition by contact, by Barresuil and Boudault, (Jour. de Pharm. April, 1844, p. 265.)—If benzoic acid is mixed with five or six times its weight of pulverized pumice-stone, and heated in a retort to a temperature not much above the boiling point of benzoic acid, and the product arising from the distillation be made to pass through a tube containing pumice-stone heated to redness, benzine and carbonic acids are the products. If the vapors of hydruret of benzoile be passed through the heated pumice-stone, benzine and carbonic oxide are formed.

Hyperoxide of Silver, (Jour. für Prakt. Chem. xxxi, p. 179.)—M. Wallquist prepared it by the action of a powerful galvanic battery upon a concentrated solution of nitrate of silver placed in a U tube. It deposits itself at the positive pole in octahedral crystals of a blackish grey color—cold water does not decompose it; oxacids decompose it with the liberation of oxygen gas; the addition of hydrochloric acid liberates chlorine; mixed with phosphorus or sulphur, it forms a fulminating compound detonating when struck.

Maynas Resin, by M. B. Lewy, (Compt. Rend. Feb. 1844, p. 242.)—This resin is furnished by the Colophyllum caloba, and when purified can be crystallized out of alcohol in very beautiful yellow crystals. Its composition is—

C^{14},	67·20
H^{9}	7·20
O^{4}	25·60
	100·00

It combines with bases, its density is 1·12; it melts at 221° Fah. The action of nitric acid of 36° furnishes a volatile acid having the characteristics of butyric acid, and the liquid that remains in the retort furnishes oxalic acid.

Guiac Resin, by MM. Pelletier and Deville, (Comp. Rend. July, 1844, p. 132.)—A volatile oil has been obtained from this resin analogous to the Spiræa oil; its composition is $C^{28} H^{16} O^{4}$, and differs from the hydrure of salicyle (Spiræa oil) by 2 equivalents of hydrogen, and like it combines with bases forming crystallizable salts. This oil is called by the discoverers the *hydrure of guiacile;* it is perfectly colorless when pure, and unalterable in the air, but in contact with potash and the air it acquires all the changes that a solution of the resin does.

Parietin, by ROBERT D. THOMSON, (Lon. and Ed. Phil. Mag. July, 1844, p. 39.)—This is a yellow coloring substance obtained from some of the lichens. It was procured by digesting the yellow parmelia in cold alcohol of specific gravity ·840, filtering, and allowing the alcohol to evaporate, when the coloring matter will be deposited in the form of fine yellow needle-shaped crystals. Composition and formula—

C^{20}, ...	65·85
H^{16}, ...	4·87
O^{14}, ...	29·28
	100·00

Parietin has been proposed as a test for alkalies,—its alcoholic solution becoming of a rich red by the addition of an alkali. Test-papers may be prepared by coloring paper with the solution. It is said to be better than turmeric for this purpose. The author thinks that it may be an oxide of an oil of the turpentine type, and mentions the following as being a probable series—

Oil of parietin, ...	$C^{40}H^{16}$
Parietic acid, ...	$C^{40}H^{16}O^{12}$
Parietin, ...	$C^{40}H^{16}O^{14}$
Oxide of parietin, ...	$C^{40}H^{16}O^{16}$

Nitrogen Gas. (Chem. Gazette, July, 1844, p. 328.)—E. MARCHAND has obtained this gas in a state of purity and with great ease, by heating in a retort a solution of chloride of lime and ammonia.

Preparation of Carbonate of Potash free from Silica. (Chem. Gaz. July, 1844, p. 328.)—One pound of crude of potash is dissolved in one pound of rain water, and four ounces of finely pulverized charcoal added to it. After standing for twenty four hours and being frequently stirred, it is filtered, when it will be found to contain no silica.

Mixture of Pure Carbonates of Potash and Soda, by M. DU MERRIL, (Chem. Gaz. Aug. 1844, p. 370.)—This mixture is frequently employed for decomposing silicates; it is prepared pure by reducing Rochelle salts to an ash in a large crucible, and washing the mass with water.

Ozone, by Prof. SCHÖNBEIN, (Bibl. Univ. de Genève, Oct. 1844, p. 420.)—For some account of this substance, see the Proceedings of the British Association published in this Journal, Vol. XLI, p. 43. M. Schönbein has been continuing his researches upon this supposed new element, and is more and more confirmed in his original views with regard to it, a detailed account of which is given in Pogg. Ann. Vol. 50, p. 616, and it would be as well to refer this. The peculiar smell observed by the electrolyzation of water is supposed to be owing to the liberation of a new body of a halogenous character, ranking with chlorine, iodine, &c. Among other things, it was discovered, 1st. That this peculiar odor remains even after the current ceases to pass. 2d. This odor is remarked only at the positive electrode—that is, in the vessel containing the oxygen gas, no trace being perceptible in the hydrogen. 3d. The odoriferous principle is easily retained for any length of time in a well-stopped vessel. 4th. The evolution of it is dependent upon the following circumstances: *a*, the nature of the metals constituting the positive electrode; *b*, upon the chemical constitution of the electrolyzed fluid; and *c*, upon the temperature of the liquid or electrode.

Of the metals, only gold and platinum, when used as electrodes, furnish the odor; neither the oxidizable metals or charcoal possessing this property. It is discovered that the odor is developed at the positive electrode, from distilled water that is mixed with chemically pure, common, and fuming sulphuric acid, with phosphoric acid, with chemically pure nitric acid, with sulphate of potash, phosphate of potash, and nitrate of potash. Watery solutions of chlorine, bromine, iodine, hydrochloric acid, and hydrobromic acid, prevent its formation; also the smallest quantity of nitrous acid, protosulphate of iron, protochloride of iron, and protochloride of zinc. If to a vessel of oxygen formed at the positive electrode, there is added a little iron, zinc, tin, or lead filings, pulverized charcoal, arsenic, bismuth, antimony, or a drop of mercury, and the vessel shaken, the odor disappears; the same is produced by heated gold or platinum, and by solutions of the protosulphate and protochloride of iron.

If gold or platinum foil be placed for a few moments in the oxygen gas containing the principle in question, they become polarized; that is, they acquire the property of exciting a current in any liquid in which they may stand in the relation of cathode, although it is of very short duration. For this polarization to take place, it is necessary that the metals should be at the ordinary temperature, and should not have the least moisture on their surface. Platinum heated, or having been kept in contact with hydrogen, loses the property of becoming polarized; their polarization is of some duration after the exposure of the metals to the atmosphere. The oxygen that has been deprived of its odor in any of the ways above mentioned does not polarize gold or platinum.

Platinum and gold become polarized when held before a stream of ordinary negative electricity passing from a point. The peculiar odor is also perceptible in the atmosphere surrounding the point from which the electricity is passing; if the point be platinum, and heated, all odor is lost until the wire has cooled down to a certain point.

From these and other facts, the author undertakes to show by a series of reasoning, that the odor is owing to a new electro-negative element ranking with chlorine, bromine, &c., and always present in air and water. In the more recent researches referred to, he has succeeded in liberating ozone by purely chemical processes—it being disengaged when phosphorus is placed at the ordinary temperature in the atmosphere, or other mixture of oxygen and nitrogen. It is also formed when a mixture of peroxide of manganese, or peroxide of lead, sulphuric acid and nitrogen, are exposed to heat. These facts would lead to the belief that nitrogen is a compound of ozone and hydrogen. If this be the case, some suppose that it will create a considerable change in that portion of chemistry relating to nitrogenous compounds; but there is no necessity why this should happen, for we might with perfect propriety consider it a compound radical without either changing its name or the formulæ of its compounds. If this conclusion is true as regards the compound nature of nitrogen, it will no doubt lead to important results in meteorology.

The author has obtained a body which he considers pure *ozonide of potassium;* it is a white powder, almost tasteless, scarcely soluble in water, easily decomposed by sulphuric acid, with the liberation of ozone.

It appears that ozone forms compounds very different from those of chlorine, bromine, &c.; for the compound of hydrogen and ozone (nitrogen) bears no resemblance to hydrochloric acid, and the ozonide of potassium little or none to chloride of potassium. With respect to its chemical affinity, it is placed between bromine and iodine,—it not acting on the bromide of potassium, but decomposing the iodide.

Some facts connected with the History of Phosphorus, by A. Dupasquier, (Compt. Rend. Aug. 1844, p. 362.)—Phosphorus as it ordinarily comes under our observation, presents different shades of color, which difference has been attributed to some modification in its molecular arrangement. This is shown not to be the case, but that phosphorus in a state of perfect purity remains colorless and transparent, when not exposed to the solar light. The author has found that the color is due to the presence of arsenic, arising from impure sulphuric acid—that acid prepared from the sulphur obtained from pyrites. When the bone earth is treated with pure sulphuric acid, a colorless phosphorus is always obtained. The arsenic combines with the phosphorus, forming the phosphuret of arsenic, which is black, and the smallest quantity suffices to color the phosphorus with which it is associated. When the arsenic is in sufficient quantity to communicate a greenish yellow color, it renders the phosphorus brittle. Phosphorus containing a very minute quantity of phosphuret of arsenic may appear colorless, but this when preserved in water will become colored even in obscurity; this appears to depend upon the formation of a little arsenious acid from the action of the oxygen of the air contained in the water upon the phosphuret of arsenic, and the subsequent decomposition of this acid by the phosphorus,—there being formed a precipitate of the metal which fixes itself to the surface and colors it in proportion to the quantity. The manner of ascertaining the presence and estimating the quantity of arsenic in phosphorus is as follows: burn an ounce of phosphorus in six or seven successive portions in a porcelain capsule, in the middle of a large plate, and covered with a large glass receiver, phosphoric and arsenious acids are formed—the combustion terminated, allow the apparatus to cool; wash, and collect the washings; separate the oxide of phosphorus by a filter, and precipitate the arsenic by hydrosulphuric acid.

The following are the effects of ordinary water upon phosphorus. When perfectly pure, it does not become colored except under the influence of light. Its purity does not prevent its being covered by degrees with a white opake coating without any brown or yellow shade; this coating has been considered by Pelouse the hydrate of phosphorus. Dupasquier has found it to contain traces of lime. In distilled water, and free from the contact of light, it is preserved without losing its transparency or whiteness; it is understood that the water must contain no air. Phosphorus plunged in water at the ordinary temperature decomposes it, with the formation of phosphoric acid and phosphuretted hydrogen; this decomposition takes place more rapidly under the direct action of the light of the sun, but it happens even in complete obscurity.

Drayton's Method of Silvering Glass. (Chem. Gazette, Nov. 1844, p. 474.)—It consists in depositing silver from solution upon glass by deoxidizing the oxide of silver on solution in such a manner that the precipitate will adhere to the glass. A mixture is made of one ounce of coarsely pulverized nitrate of silver, one half ounce spirits of hartshorn, and two ounces of water; which, after standing for twenty four hours, is filtered and mixed with three ounces of spirits of wine of 60° or naphtha; from twenty to thirty drops of oil of cassia are then added; and after remaining for about six hours longer, the solution is ready for use. The glass to be silvered with this solution must have a clear and polished surface; it is to be placed in a horizontal position, and a wall of putty formed around it, so that the solution may cover the glass to the depth of from an eighth to a quarter of an inch. After the solution has been poured upon the glass, from six to twelve drops of a mixture of oil of cloves and spirits of wine (in the proportion of one part by measure of oil of cloves and three of spirits) are dropped into it at different places; or the diluted oil of cloves may be mixed before it is poured upon the glass. When the deposit is obtained, which takes place in an hour or two, the solution is poured off, and as soon as the silver is perfectly dry, it is varnished with a composition formed by melting together equal quantities of bees' wax and tallow.

Tests for Coloring Substances in Wine, by M. Jacob, (Chem. Gazette, Aug. 1844, p. 346.)—It is found that the basic acetate of lead on the one hand, and sulphate of alumina with carbonate of ammonia on the other, are all that is necessary to discriminate between the various coloring materials used in coloring wine.

	Sulph. alum. and carb. am.	Basic acetate of lead.
Ordinary red wine,	grayish precipitate,	bluish gray precipitate.
Logwood,	dark violet,	blue.
Brazil wood,	rose red,	wine red.
Wild poppy,	grayish,	dirty gray.
Recent juice of danewort,	bright violet,	bluish gray.
Fermented " "	bright violet,	beautiful grass green.
Elder berries,	bluish gray,	dirty green.
Privet berries,	pale green,	dirty green.
Litmus,	rose red,	bluish gray.

When litmus is present in small quantities, it is not indicated by the above test; the wine should then be cautiously evaporated to the consistency of an extract—a small quantity of which is dissolved in a little pure water and tested. The sulphate of alumina and carbonate of ammonia are not mixed previously, but are added alternately to the wine.

Osmium, by E. Fremy, (Compt. Rend. Sept. 1844, p. 468.)—In the abstracts for this Journal, Vol. xlviii, p. 185, Fremy's method of obtaining this metal in a state of purity was given; he has since published his entire research upon this substance. The atomic weight was determined by burning a weighed portion of the metal in oxygen gas, condensing the acid formed, and estimating its quantity; it is found to be 99·76, (hydrogen 1,) very nearly that given by Berzelius.

The most interesting compounds described by the author are the osmites, OsO^3+X. The osmite of potash is the most important of them all, and is formed when the osmate is placed in contact with a body having considerable affinity for oxygen. The ease with which the osmite of potash is prepared, makes it a convenient method of determining the quantity of osmic acid present in a liquid—thus, saturate the osmic acid solution with potash, and add a few drops of alcohol, which determines both the formation and precipitation of the osmite; the osmite is then washed with alcohol and weighed. The osmite of potash is red, soluble in water, completely insoluble in alcohol, crystallizes in octahedrons, but it cannot be crystallized out of water, as that decomposes it; but may be obtained in the crystalline form by putting a very alkaline solution of osmate of potash in contact with nitrite of potash, when the osmite forms gradually and crystallizes, (crystals contain two atoms of water.) Its solution in water decomposes tolerably rapidly into osmate of potash and deutoxide of osmium.

The action of ammonia upon a cold solution of the osmite of potash is curious, forming a body having for its composition $OsO^2\,AzH^2$, (the oxide of osmium in combination with the radical AzH^2, that Gay-Lussac and Thenard obtained in combination with potassium and sodium.) It is difficult to isolate this compound, but it is easily obtained in combination under the form of *osmiamide.* Its compound with hydrochlorate of ammonia is procured by adding together solutions of this salt and osmite of potash, when a yellow precipitate is formed having for its formula $OsO^2 AzH^2 + HCl AzH^3$.

Hydrosulphite of Soda, by M. Plessy, (Ann. de Chim. et de Phys. June, 1844, p. 182.)—The author first prepares the bisulphite of soda by passing a current of sulphurous acid through a solution of carbonate of soda, until the acid is no longer dissolved. This bisulphite is converted into sulphite by adding carbonate of soda until effervescence ceases; the liquid is now boiled with flowers of sulphur for fifteen or twenty minutes, stirring frequently; then separate from the excess of sulphur, evaporate to the consistency of syrup, and allow it to stand. If there should happen to be any sulphate present it separates. After twenty four hours the clear liquid is decanted, concentrated, and allowed to crystallize.

Xanthic Oxide in Guano. (Chem. Gazette, Aug. 1844, p. 363.)—M. Unger has discovered the presence of this substance in guano. Treat the guano with hydrochloric acid, precipitate with caustic potash, which redissolves a small portion of the precipitate, (the oxide in question;) to separate it from the potash, all that is necessary to do is to pass a current of carbonic acid through the solution, or by the addition of hydrochlorate of ammonia, when it deposits as the ammonia evaporates.

To detect the presence of Sugar in Diabetic Urine, by Dr. Cappezuoli, (Gaz. Toscan. and Chem. Gaz. Aug. 1844, p. 369.)—The fresh urine is placed in a cylindrical vessel, and to it added a few grains of the hydrated oxide of copper, and enough of a solution of caustic potash to render the urine alkaline; the whole is shaken together, when it becomes troubled from the precipitation of the phosphates, and from the oxide of copper which it contains in suspension. The urine gradually becomes clear from the subsidence of the voluminous deposit, which is at first of a sky-blue color, but at the end of a few hours a canary-yellow circle is seen to form on its surface, and gradually to pervade the mass; subsequently a red color more or less deep in the form of a zone replaces the yellow either wholly or in part. This phenomenon, which is generally completed in twenty four hours, is owing to the reaction of the sugar on the oxide of copper, which is gradually deprived of its oxygen. If the reaction does not appear in twenty four hours a little potash will develope it.

Carbonate of Ammonia and Magnesia, and Carbonate of Ammonia and Zinc, by M. Favre, (Ann. de Chim. et de Phys. April, 1844, p. 474.)—Both are formed by agitating the carbonate of ammonia with the respective carbonates recently prepared, when the filtered solutions will deposit crystals of the double salts, unalterable in well corked phials. Formulæ,

$$CO^2 MgO + CO^2 NH^4 O + 4Aq.$$

$$CO^2 ZnO + CO^2 NH^4 O + 4Aq.$$

New Method of Analyzing the Blood, by L. Figuier, (Ann. de Chim. et de Phys. Aug. 1844, p. 506.)—This method is based upon the fact pointed out some years ago, that when blood deprived of its fibrine was mixed with a solution of a neutral salt and thrown upon a filter, scarcely any of the globules passed through. The author has been enabled to retain all the globules by using a solution of sulphate of soda, marking 16° to 18° Baumé; adding two volumes of this solution to one volume of blood.

The blood furnished by bleeding is beat with a small bundle of whalebone switches at the moment that it issues from the vein; the fibrine separates and adheres to the switches. The blood is now passed through fine linen to collect that portion of the fibrine that does not adhere to the whalebone; both portions are added together well washed with water, dried at the temperature of boiling water, and weighed; (previous to weighing, if it be desired to detach the small quantity of fatty matter adhering, digest in ether.) By ascertaining the entire amount of blood taken from the patient, we are thus enabled to tell the relative portion of fibrine.

The next step is to take about three ounces of defibrinated blood, dilute it with twice its volume of a solution of sulphate of soda, marking 16° to 18° Baumé; throw this upon a filter that has been previously weighed and moistened with a solution of sulphate of soda. The serum filters readily, and is of a yellowish color. The filter cannot be washed with cold water, as this dissolves the globules; but hot water of 195° Fah. coagulates them, and enables one to accomplish this in the following manner: take the filter from the funnel and immerse it in a cup of boiling water; repeat this two or three times, and all the sulphate of soda will be washed away; dry the filter and its contents at about 212°, and weigh.

To separate the albumen from the serum deprived of its globules, heat it to ebullition in a capsule. The albumen coagulates; it is thrown on a small piece of fine linen, washed, dried at 212° Fah. and weighed. To ascertain the quantity of water in the blood, an ounce of it is taken and evaporated to dryness in a water bath; the weight of what remains indicates the relative proportion of water and solid elements. The soluble salts of the serum are represented by the difference of the weight of the blood employed and the amount of albumen, of water, of fibrine, and of globules, directly determined. The following is the result of an analysis of blood from a diseased patient:

The blood upon beating furnished for 8 ounces (the quantity taken from the patient) 10·4 grains of fibrine. 3 ounces of the blood separated from the fibrine, and filtered with sulphate of soda, gave 180 grains of globules. The serum filtered from the last by heating, furnished 80 grains of coagulated albumen. 1 ounce of the original blood evaporated to dryness, gave a residue of 85 grains. From these the blood is seen to contain—

Water, ...	802·9
Globules, ...	130·6
Fibrine, ...	3·9
Albumen, ...	50·6
Inorganic salts, ...	12·0
	1000·0

The author recommends the employment of saline solutions for the purpose of separating the globular matter from organic fluids, as milk, mucus, chyle, lymph. M. Figuier has also made a chemical examination of the globules, and he thinks it probable that they contain a small quantity of fibrine, albumen, and the coloring matter of the blood.

Cause of Diabetes, by L. Mialhe, (Ann. de Chim. et de Phys. Sept. 1844.)—It is known that in a healthy state animals may feed on sugar, gum, &c. without any appearance whatsoever of these substances in the urine or other secretions ; but in the disease called diabetes, this kind of food appears to undergo little or no change, and the urine is found to contain more or less sugar, or a substance resembling gum. The result of the present experiments has been to show that hydrocarbonaceous food, such as grape sugar, gum, starch, &c. does not undergo assimilation until the alkalies of the blood have transformed them into a peculiar substance, the nature of which has not yet been examined; if however this transformation does not take place, they undergo no change, and are excreted by the kidneys. The reason why saccharine and farinaceous matter does not undergo the requisite change in the diabetic patient is explained as follows: individuals suffering under diabetes do not perspire, or but very slightly; as the secretions of the skin are acid, it follows that when they are suppressed, the presence in the blood of free alkalies or their carbonates becomes impossible, being neutralized by the acids not excreted; consequently the saccharine matter used as food cannot undergo the *change necessary* prior to its assimilation, and the kidneys endeavor to disembarrass the blood of what is now foreign and noxious. This fact suggests, as the curative means for diabetes, diaphoretics and alkaline preparations.

Volatile Acids of Butter, by J. U. Lezch, (Ann. der Chem. und. Pharm. Vol. 49, p. 212.)—The acids that have been obtained are—

Butyric acid, ...	$C^8\ H^8\ O^4$
Caproic acid, ...	$C^{12} H^{12} O^4$
Caprylic acid, ...	$C^{16} H^{16} O^4$
Capric acid, ...	$C^{20} H^{20} O^4$
Vaccinic acid, ...	$C^{20} H^{20} O^7$

The last acid represents an atom each of butyric and caproic acids, minus an atom of oxygen; it is not constant, being found only occasionally. These acids are obtained by saponifying butter with potash in a convenient apparatus, then adding sulphuric acid and distilling, when the volatile acids will come over with the water; they are saturated with barytic water, concentrated, and afterwards reduced to dryness in a retort; the residue is boiled with five or six parts of water, which dissolves a portion; the solution separated and allowed to cool, deposits crystals of caproate of baryta in the form of silky needles, that are to be separated from the mother water, which when evaporated by the heat of the sun, deposits the butyrate of baryta; both of these salts are purified by recrystallization. When vaccinic acid is present, it generally takes the place of butyric and caproic acids, and is deposited from the concentrated solution in combination with baryta in groups of small crystals that effloresce. The baryta salts of difficult solution that are left in the retort are dissolved in as much boiling water as will just hold them in solution, filtered while hot; on cooling, the caprate of baryta is deposited in minute scales of a fatty lustre—upon concentrating to about three fourths, an additional quantity of this salt is obtained. The mother water, exposed to the heat of the sun, furnishes the caprylate of baryta; these are also purified by recrystallization. All the acids can now be obtained by heating their barytic salts in a retort with dilute sulphuric acid.

Atomic Weights of Copper, Mercury, and Sulphur, by ERDMANN and MARCHAND, (Chem. Gazette, Sept. 1844, p. 399.)—That of the copper was estimated by decomposing a known quantity of binoxide of copper in a current of hydrogen gas, and weighing the residue of the metallic copper; it was done with all the minute precautions necessary; the result was 31·7, (hyd. 1.) The atomic weight of mercury was estimated by decomposing a known quantity of pure oxide of mercury, by copper turnings and charcoal, collecting the metallic mercury formed, and estimating its weight; the result was 100. That of sulphur was ascertained by decomposing pure vermilion with copper filings and heat, and ascertaining the amount of mercury; the atomic weight is 16.

Deoxidation of the Ferridcyanide of Potassium, (red prussiate of potash, Fe^2Cy^3+3KCy,) *and of the Salts of the Peroxide of Iron*, by Prof. SCHÖNBEIN, (Jour. für Prakt. Chem. Vol. 30, p. 129.)—The results of the author's experiments upon the red prussiate of potash are certainly improperly styled deoxidation, as there is no oxygen in the compound in question, nor is it necessary to presuppose the agency of oxygen in all cases in bringing about the reactions to be mentioned; decyaniding would perhaps be a more correct term, for it appears that certain substances convert the ferrid into the ferrocyanide of potassium—a cyanide containing less cyanogen. Any of the metals, including silver and even gold, platinum and palladium under certain circumstances, produce this change, it being facilitated by the access of air. The experiment is easily made by placing a piece of antimony, zinc, bismuth, lead or tin, in a solution of the salt in question, when it soon acquires the property of forming a blue precipitate with the persalts of iron, due to the formation of the ferrocyanide of potassium. A simple manner of demonstrating the same fact consists in conveying a drop of the liquid to a bright surface of one of the metals, and adding a drop of a solution of nitrate of iron, when immediately after the mixture has taken place the metal becomes coated with a layer of prussian blue. On gold, platinum, and palladium, this change takes place but very slowly. Other substances besides the metals produce it, as phosphorus—hydrogen in the nascent state, as when disengaged by the agency of electricity from a plate in the solution. Hydrogen when combined with sulphur, selenium, phosphorus, arsenic, antimony, and tellurium, will do the same even in the gaseous state. Sugar produces the change when boiled with a solution of the salt; also uric acid and creosote. All the bodies that decompose the ferridcyanide are found also to reduce the persalts of iron to the state of the protosalts. And it may be as well to mention here that J. Stenhouse (Chem. Soc. Mem. Vol. 2, p. 121) has ascertained that fresh grass and other green vegetable matter, peat, and wood coal, have the same effect upon the persalts of iron.

Decay and Mouldering of Wood, by M. HERMANN, (Jour. für Prakt. Chim. Vol. 37, p. 165, and Chem. Gaz. Oct. 1844, p. 423.)—It is shown in these investigations that wood in its decay undergoes two entirely different processes, during which both oxygen and nitrogen are absorbed, and nitroline and humus are formed, the latter succeeding the former; by humus is here meant all parts of rotten wood soluble in alkalies. From 1 atom wood$=C^{36}H^{22}O^{22}$, 4 atoms water, 4 atoms carbonic acid, and 1 atom nitroline, can be formed by the absorption of 4 atoms oxygen and 1 atom nitrogen. M. Hermann shows that decayed wood contains three distinct organic substances—nitroline, ligneo-humous acid, and humus. One kind of nitroline gave—

C^{32},	57·1
H^{18},	6·0
O^{14},	32·9
Nit.^{1},	4·0
	100·0

	Fresh decomposed wood.	Decomposition farther advanced.
Nitroline,	61·0	18·8
Ligneo-humic acid,	21·0	53·6
Humus,	17·5	26.6
Ammonia,	0·5	1·0
	100·0	100·0

The absorption of nitrogen by decaying wood, and the subsequent decay of the nitroline forming ammonia, shows how important decayed vegetable matter must be in the economy of the vegetable world.

Fluoride of Iodine, by H. B. LEESON, (Chem. Soc. Mem. Vol. 2, p. 162.)—It is prepared by passing the gas generated from one part of the peroxide of manganese, three of pure fluor spar, and six of concentrated sulphuric acid, through water in which iodine is diffused, (contained in a glass vessel,) until the whole of the iodine is taken up. A lead retort and conducting tube were made use of; the tube did not appear to be acted upon, nor was any lead traceable in the product formed, which deposits itself in crystalline scales similar in appearance to those of iodide of lead. Fluoride of bromine is formed in the same way, but from its extreme solubility does not yield a crystalline deposit.

The Products of the Decomposition of Narcotine, by Prof. WÖHLER, (Jour. der Chem. und Pharm. April, 1844, p. 1.)—This research was made with the object of ascertaining if any light could be thrown upon the origin and constitution of the alkaloids. Narcotine was the first noticed; it was decomposed by treating its solution with an excess of sulphuric acid and peroxide of manganese, until carbonic acid ceased to be evolved. The products of the decomposition are an acid containing no nitrogen, an organic base, and carbonic acid.

Opianic acid is the acid formed; it has already been noticed by Wöhler and Liebig. It crystallizes in thin narrow prisms, colorless, of a faintly bitter taste, slightly soluble in cold water, melts at 284° Fah. without parting with its water. It undergoes a remarkable change on being heated, the melted acid not returning to its original state, and losing some of the properties previously possessed, without any alteration in its composition. Composition of the acid, $C^{20} H^{8} O^{9} + HO$. It combines with oxides forming salts, and with the oxide of ethyle to form opianic ether.

Opianate of ammonia, when cautiously heated at a temperature somewhat above 212° Fah. until ammonia ceases to be given off, gives rise to a substance called *opiamon*, composed of $C^{40} H^{17} N O^{16}$. The action of the alkalies upon this last is to produce a nitrogenous compound styled *anthopenic acid*, characterized by the yellow color of its salts; this last is itself a lemon yellow crystalline powder. The action of sulphurous acid upon opianic acid is to form a new compound, *opiano-sulphurous acid*, which furnishes beautiful crystalline salts with the oxide of lead and barium, has a peculiar bitter taste at first, but a sweetish after taste. Composition $C^{20} H^{6} O^{7}, 2SO^{2} + HO$. There are yet other singular compounds formed by the action of different reagents upon opianic acid. *Cotarnine*, the organic base obtained by the action of the peroxide of manganese and sulphuric acid on narcotine, is composed of $C^{26} H^{13} NO^{5}$.

J. BLYTH (Chem. Soc. Mem. Vol. 2, p. 163) has also shown, that a similar decomposition takes place by the action of the bichloride of platinum upon narcotine, having obtained the opianic acid and cotarnine. This fact accounts for the different formulæ for narcotine given by various authors, the atomic weight being estimated from the double chloride of platinum and narcotine, which, unless prepared with great care, is likely to undergo partial decomposition. The following appears to be the correct formula for narcotine, $C^{46}H^{25}NO^{14}$. The other products furnished by the reaction of bichloride of platinum upon the alkaloid, are hempinic acid, $C^{10}H^{5}O^{6}$, and narcoginine, a base, $C^{36}H^{19}NO^{10}$. This last exists only in the form of a double salt in combination with chloride of platinum; any attempt to separate it resolves it at once into narcotine and cotarnine.

Analysis of Alloys of Tin and Antimony, (Chem. Gaz. Aug. 1844, p. 347.)—CHEVALIER and LASSAIGNE have found that on treating an alloy of these two metals with muriatic acid, none or very little antimoniuretted hydrogen is formed, while the antimony separates as a black powder. If, on the contrary, the alloy is treated with nitric acid, the yellow insoluble mixture of oxide of tin and antimonious acid separated, ignited, (when it becomes green,) and treated with sulphuric acid and water,—an abundant evolution of antimoniuretted hydrogen gas takes place, which on ignition deposits large glittering films of antimony.

Test for Bile, by M. PETTENKOFFER, (Lancet, Oct. 1844.)—Add to the fluid supposed to contain bile concentrated sulphuric acid until it becomes hot, and then drop into it a solution of sugar; the presence of the bile is manifested by the mixture becoming of a deep pink or red color, varying in intensity.

2. *New instrument for the solidification of carbonic acid.*

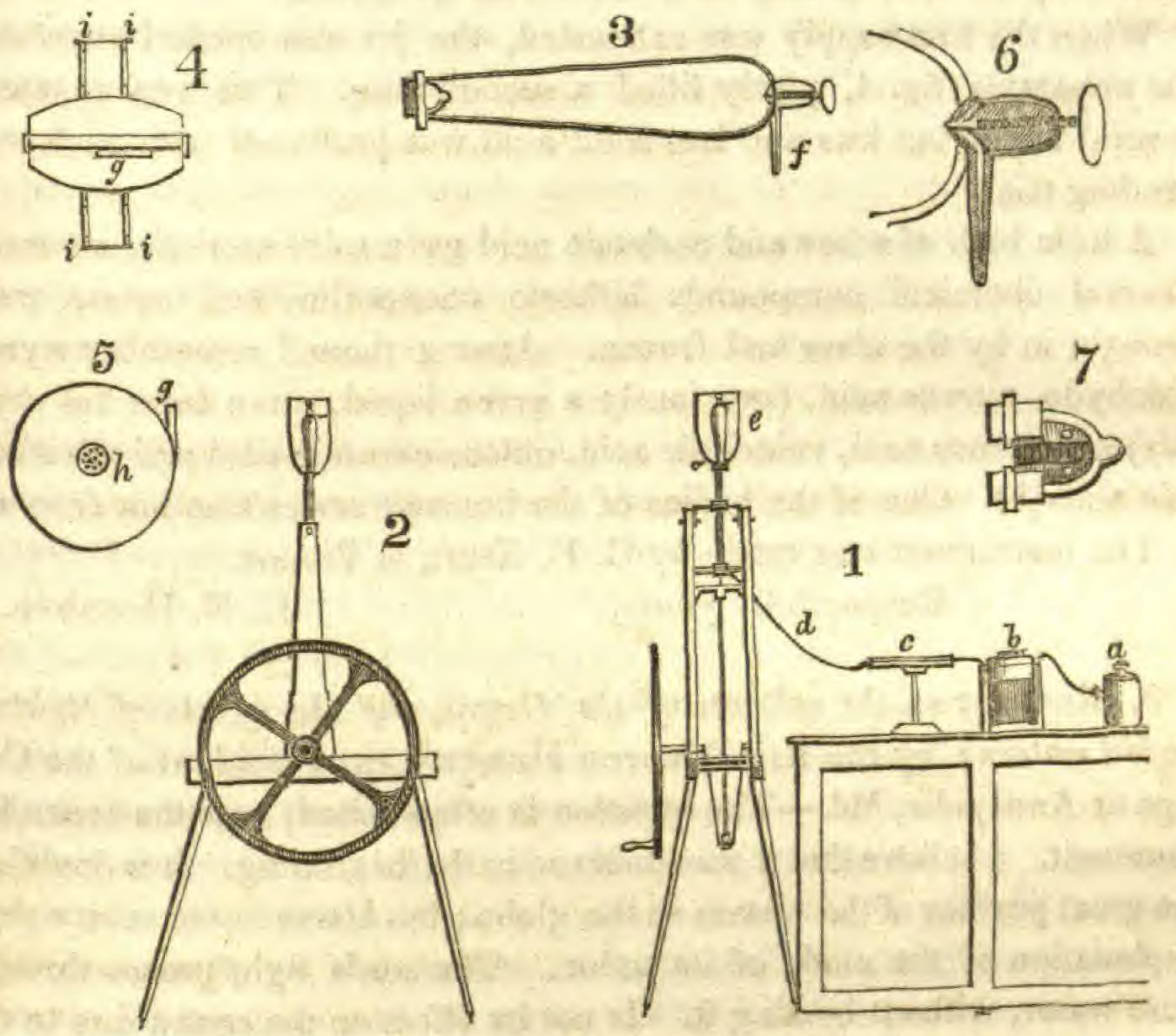
Giessen Laboratory, March 21, 1845.

Messrs. Editors,—An instrument for the solidification of carbonic acid arrived here a few days since from Vienna, and having been experimented with, in the presence of the class, proved so simple and safe, that I have thought a sketch of it might perhaps not be uninteresting to you.

It is essentially a convenient forcing pump, to which is attached a cylinder sufficiently strong to resist the pressure necessary to the liquefaction of carbonic acid. The chief difference between it and those, one of which burst in Paris, with such frightful effects, is, that the evolution of gas is entirely disconnected with the cylinder in which condensation is produced. This prevents all danger from the disengagement of hydrogen in a surplus of sulphuric acid. The cylinder had been previously subjected to a pressure of a hundred and fifty atmospheres, and as carbonic acid liquefies below one third of this pressure, the instrument was perfectly safe. A sheet of wrought iron, not more than the sixteenth of an inch thick, rolled into form and carefully welded, is the substitute for the massive cast iron mortars that were formerly used.

The following references to the diagrams which I send you, will readily explain the manner of using it.

Gas was permitted to accumulate in the gasometer *b* to the amount of about a gallon and a half, and then by the forcing pump driven into the cylinder. When this volume had been repeatedly forced into the



8 5 3 2 1 feet. Scale for figs. 1 and 2.

2 1 feet. " " " 3, 4 and 5.

1. Side view of the instrument, with apparatus and connections for supplying carbonic acid.—2. End view of the same.—*a*. Evolution flask containing $2Co_2+NaO+SO_3$.—*b*. Gasometer.—*c*. Ceca tube.—*d*. Caoutchouc tube about four feet long.—*e*. Copper vessel for water or snow to keep the cylinder cold.—3. Cylinder for condensing the gas.—4. Apparatus for solidification, made of sheet iron tinned.—5. Inner view of one half.—6. Enlarged view of the valve for the escape of gas into 4.—7. Valve controlled by coiled wire spring at the other extreme of the cylinder 3.—*g*. Tube fitting upon *f*.—*h*. Apertures for the escape of gas in the process of solidification.—*i i*. Double cylinder to prevent the cold from affecting the hands of the operator.

cylinder, it was unscrewed and weighed, to ascertain the amount of carbonic acid it contained. This was done several times, until found to be increased in weight by nine and a half ounces of acid, when it was detached as in fig. 3, and the cock *f*, in which is an aperture of scarcely more than a pin's diameter, was sheathed by *g* of fig. 4. Thus arranged, one operator holding the solidifying apparatus in his two hands by the double cylindrical handles *i i*, *i i*, and the other unscrewing the valve at *f*, the acid rushed through the cock into fig. 4. The vaporized portions escaped through *h*, while the jet was continued some twenty seconds, and the solid snow-like ball was found to quite fill the vessel. Fig. 4 opens in the middle, and while the solid acid lies in one half, the other may be used to remove it in smaller quantities.

When the first supply was exhausted, the jet was opened anew and the apparatus fig. 4, partly filled a second time. This was repeated several times, but less and less solid acid was produced with each succeeding trial.

A little bath of ether and carbonic acid gave solid mercury as usual. Several chemical compounds hitherto unexperimented upon, were brought in by the class and frozen. Among these I remember styrol, aldehyde, nitrous acid, (previously a green liquid, gave beautiful crystals) sulphurous acid, valerianic acid, chloro-chromic acid and nitro-bromic acid.(?) One of the bodies of the benzoyl series was not frozen.

The instrument was made by C. E. Kraft, in Vienna.

Respectfully yours, E. N. Hosford.

3. *Remarks on the saltness of the Ocean, and the effects of light on turbid waters;* by the Rev. Hector Humphreys, President of the College at Annapolis, Md.—The question is often asked, how the ocean became salt. I believe that it was made so in the beginning. It is doubtless the great purifier of the waters on the globe; but I have never seen a good explanation of the mode of its action. The sun's light passes through pure water, without heating it. Is not its effect on the ocean due to the salt combined with its waters? In rivers which carry *sediment*, the light is arrested by the floating particles, which are thus warmed, and impart heat to the water. This accounts for the quick evaporation of *turbid* streams, such as the Red River, whose size is not enlarged by many considerable tributaries, in a thousand miles of its course. This extraordinary evaporation in that stream, may be owing in part, to the earthy matter in the current thus arresting the light. If we throw the focus of a burning glass into distilled water, no heat is communicated, unless some substance is placed there to receive the rays. The salt, with which the waters of the ocean are charged, has a strong affinity for heat; and thus keeps its mean temperature higher than that of other

waters on the earth; while rivers and lakes are heated, mainly, by *conduction.* That salt water is warmed more quickly than fresh, is shown by the pyrometer. In two experiments the index moved over 2600 divisions of the scale in ten minutes, when the trough was filled with fresh water; and in a little over *five* minutes when salt water was used. In thirteen minutes the index reached 3600, where fresh water boiled; but the index passed to 4000 with salt water, in *eight* minutes, where it boiled. This agrees with the relative *expansibility* of salt water and pure; the latter being enlarged a tenth less than the former, when heated from 32° to 212° F. The rate of *cooling* is also different. Boiling fresh water was left to cool, and subsided to 132° in ten minutes, while salt water subsided only to 140°. The waters of the ocean, then, *take* heat more rapidly, and *retain* it longer than fresh-water lakes, which, when large, remain cold even in midsummer. The heat from the bottom, the shores, and the air, does not raise the temperature of Lakes Superior and Michigan much above that of iced water in the hot season. But for the presence of some such substance in the waters of the ocean, they would never be warmed. The substance to be employed for this purpose, must be freely soluble in water and have strong attraction for heat. The *sulphate of soda*, for example, would have furnished these qualities, but would not have afforded a supply for man, almost as needful as water itself, the salt for common use, which is obtained in such immense quantities by solar evaporation.

It may be said that both water and salt, are remarkably *transcalent;* but it does not appear that substances which suffer the solar beam to pass with the greatest facility, will permit it to penetrate, to indefinite depths. It is not probable that the *calorific* portion of the sun's light, affects the ocean much below the surface.

This consideration may be of some avail to explain the *currents* of the ocean, which are caused, in a great measure, by the difference of specific gravity of the waters, and the motion thus given to them by the diurnal revolution of the globe. The heavier particles incline to the equator, and the lighter to the poles.

The color of sea water is, doubtless, affected by the sun's light, at least in some measure, acting on the substances which it contains.

4. *Kenawha Gas*—communicated by Mr. JAMES A. LEWIS, of Kenawha C. H., Va., being an extract, somewhat abridged, from the Charleston Republican.

The existence of large quantities of gas at various points, throughout the whole extent of the salt region on the Kenawha river, was known to the first white men that explored this beautiful valley. It appeared escaping through apertures in low grounds, and springs of water.

As a company of the earliest explorers encamped on the banks of the river, one of their number, in a dark night, took a torch to light his way to the spring near by the encampment, and in waving it over the spring, to his great consternation it took fire, the gas burning upon the surface of the water. It was thence called the "Burning Spring," and is the same that is mentioned by Mr. Jefferson in his Notes on Virginia. It is still there, but, as we saw it last week, a mere mud-puddle. The water, agitated by the gas, resembles a boiling pot. It readily ignites, and for a short time it burns with a blue blaze on the surface of the water; even when the water is dried up the gas will burn brilliantly between one rain and another.

When, in process of time, the salt manufacturers, either from a failure of the salt water above the stratum of rock, some 15 or 20 feet lower than the bed of the river, or for the purpose of procuring the water in greater abundance, sunk their wells by boring far below the surface of the rock, the gas, in various quantities, made its appearance in the wells, in some instances jetting the water into the air, when being ignited, it spread the flame about, to the no small amazement and terror of the workmen. When this happened they used to say, "*the well is blowed.*" The stream of gas, however, soon subsided, or acted only with sufficient power to force the water up into the gum or shaft, which is part of the trunk of a sycamore tree, about four feet in diameter, hollowed out so that the shell is not more than four inches thick. From the gum it was pumped into the cistern or reservoir.

Our salt wells are commenced near the edge of the river at low water. The gum is sunk down to the rock, a distance of from 15 to 20 feet, the lower end resting tightly on the rock. The other end is usually a few feet above the ground. This excludes the fresh water above the rock, and serves as a reservoir to receive the salt water when it is reached by boring through the rock and the various strata of earth.

Three years ago, William Tompkins, Esq. first obtained a steady and permanent stream of gas, of sufficient power, not only to force the water up from the depth of a thousand feet into the gum, but to carry it into the reservoir elevated many feet above the bank of the river. This saved the expense of a pump, which is worked by a steam engine. In a short time it occurred to him that this gas could be turned to a still more useful purpose. He therefore erected, over the reservoir or cistern, a gasometer, which is simply a hogshead, placed upright, in the lower end of which is inserted the pipe that conveys the water and the gas from the wells, the water running out through a hole in the lower end, and in the top is inserted a pipe that conveys the gas to the mouth of the furnace. When ignited, it produces a dense and intensely heated flame along the whole furnace under the row of kettles, 100 feet long by 6 deep and 4 wide. This saves the expense of digging and hauling coal.

Subsequently, Messrs. Warth & English, whose works are on the opposite side of the river, obtained a similar stream of gas, which has been used successfully in the same way ; and more recently Mr. Dryden Donnally, Mr. Charles Reynolds, and some few others, produced a partial supply of gas to heat their furnaces in the same way.

But the most remarkable phenomenon in the way of natural gas here, and we have no doubt in the whole world, is that at the works of Messrs. Dickinson & Shrewsbury, which has been exhibited for nearly two months past. In this well the gas was reached at the depth of one thousand feet. What the upward pressure of the gas to the square inch is, through the aperture, which is three inches in diameter, we are unable to tell, and perhaps it would be impossible to ascertain. It has never had a free and unobstructed vent. There is now at the bottom of the well an iron sinker, a long piece of round iron nearly filling the aperture ; on this are 600 pounds of iron, and about 300 feet of auger-pole used in boring, in pieces of 10 and 20 feet in length, with heavy iron ferules on the end, screwed into each other. Notwithstanding all this obstruction, a stream of water and gas issues up through a copper tube, 3 inches in diameter, inserted into the well to the depth of 500 feet, with the noise and force of steam generated by the boilers of the largest class of steamboats. It is computed that a sufficient quantity of gas comes from this well to fill, in five minutes, a reservoir large enough to light the city of New York during twelve hours. When we reflect that this stream of gas has flowed, unabated, for nearly two months, what must be thought of the quantity and the facility of manufacturing it down below ! In the springs hard by, and in the other wells, (with perhaps the exception of that of one or two others,) there appears, as yet, to be no diminution in the quantity at any place where it has heretofore been known to exist.

5. *Bromine and Iodine.*—Prof. W. W. Mather, at Athens, O., writes under date of Jan. 20, 1845—" I have found bromine and iodine in the bittern of the salt springs of this vicinity. They are not very abundant, but by improved methods of extraction, I can supply any demand for bromine or its common combinations ; I can supply it as cheap as any one. I have extracted bromine pure, and formed various compounds with it, as bromide of iodine, hydrobromic acid, hydrobromates of potassa and soda, bromates of potassa, soda and of lime."

We with pleasure record this fact, and can add that we have received similar statements from Pittsburg, in Pennsylvania, and other places in the west.

6. *Abstract of a Meteorological Register for the year* 1844, *kept at Steubenville, Ohio;* by ROSWELL MARSH.

MONTHS.	Thermometer—mean. 6 A. M.	12 M.	6 P. M.	Range at the same times.			Highest.	Lowest.	Barometer—mean. 6 A. M.	12 M.	6 P. M.	Range at the same times.			Highest.	Lowest.	Melted snow and rain. Inches.	Time of do. Days rain.	Days snow.	Winds. Days northwardly.	Days southwardly.	Atmosphere. Days clear.	Days cloudy.
January, . . .	24	30$\frac{3}{4}$	29	43	43	36	56	4	29·34	29·34	29·33	·97	·98	·82	29·68	28·65	1·91	7	12	19	12	10	21
February, . . .	26$\frac{2}{3}$	38$\frac{1}{3}$	35	37	34	31	56	6	29·42	29·42	29·42	·58	·71	·68	29·71	29·00	·90	5	8	21	8	11	18
March, ...	35$\frac{1}{3}$	45$\frac{1}{3}$	42$\frac{2}{3}$	33	35	30	64	19	29·40	29·41	29·40	·80	·81	·82	29·81	28·98	3·38	16	9	21	10	12	19
April, ...	49$\frac{2}{3}$	71$\frac{1}{6}$	65$\frac{1}{2}$	29	30	32	86	34	29·50	29·52	29·51	·33	·37	·35	29·63	29·26	1·40	9		17	13	18	12
May, ...	56$\frac{1}{6}$	70$\frac{5}{6}$	66$\frac{1}{2}$	32	29	32	84	36	29·42	29·45	29·41	·62	·64	·77	29·72	28·95	4·52	15		12	19	9	22
June, ...	61$\frac{1}{3}$	75$\frac{1}{2}$	71$\frac{1}{3}$	24	26	25	88	46	29·45	29·47	29·45	·40	·43	·45	29·73	29·28	4·35	14		19	11	13	17
July, ...	68	82	77$\frac{1}{2}$	21	24	20	92	56	29·42	29·44	29·43	·40	·48	·37	29·68	29·20	5·15	11		19	12	16	15
August, . . .	61$\frac{3}{4}$	77$\frac{3}{4}$	72	26	32	24	90	52	29·39	29·42	29·40	·49	·49	·49	29·60	29·10	4·70	15		13	18	12	19
September, . .	55	72	67$\frac{1}{2}$	32	41	45	85	34	29·51	29·53	29·53	·65	·61	·52	29·72	29·05	2·65	7	2	26	4	18	12
October, . . .	41$\frac{1}{3}$	54	51$\frac{1}{2}$	27	32	31	68	27	29·43	29·45	29·43	·85	·95	·83	29·80	28·85	4·21	10	1	20	11	7	24
November, . .	35	45	43	30	40	45	65	20	29·40	29·40	29·40	·50	·60	·66	29·70	29·04	2·70	6	1	17	13	12	18
December, . .	27	31	30	28	30	29	48	12	29·45	29·45	29·45	·42	·40	·40	29·62	29·20	2·80	7	4	18	13	12	19
Year, . . .	45$\frac{1}{4}$	58	54$\frac{1}{2}$	74	79	76	92	4	29·43	29·44	29·43	1·15	1·11	1·00	29·81	28·65	38·67	122	37	222	144	150	216

Steubenville is in lat. 40° 25′ N., lon. 3° 40′ W. from Washington City. Altitude above tide water at Baltimore 670 feet. The thermometer and barometer are suspended in an open wooden box, which hangs against a brick wall in an open verandah on the north side of a house, about fourteen feet from the ground.

7. *Fossil Remains from Algoa Bay, near the Cape of Good Hope, from Mr. Baynes.*—They consist of several skulls and some bones of the extremities of several species of reptiles, of the most extraordinary character. Some appear to be closely allied to, if not identical, with the *Rhynbrosaurus*, (Medals of the Creation, Vol. II, p. 759,) but others belong to a creature, which appears to connect the Chelonians with the Saurians. It has two teeth or tusks; one on each side the upper jaw, while the rest of the jaw seems to have had only an investment of horn like the true Chelonians. Mr. Owen gave a lecture upon these bones, which the writer of this notice did not hear, but he had opportunity to take a hasty glance at the bones. Mr. Baynes himself detected the true nature of the fossils, and described them in the Cape of Good Hope Journal as reptiles with two teeth, and proposed the name of *Binodon*, which Mr. Owen has changed.—(Letter from London.)

8. *Fossil Footmarks and Rain-drops.—Extract of a Letter from* James Deane, M. D., *dated Greenfield, June* 18, 1845.

To the Senior Editor: My Dear Sir:—My recent explorations for Ichnolites have been successful, and I am confident from the deep interest you have ever manifested in these fossils that a brief description of the results will be acceptable. My search was limited to Turner's Falls, a locality remarkable for the beautiful preservation of the impressions. When the excavations through the rock were completed to the depth of six feet, the workmen came to three or four thin layers of smooth, bright sandstone, impressed with a great profusion of footmarks of birds and quadrupeds, and impressions of falling rain. The strata lying in contact, the inferior faces were consequently diversified with reliefs. The aggregate of impressions is over one hundred, belonging to four or five described and as many undescribed species. The largest footstep is six inches in length with a stride of twenty eight inches; the smallest is two inches in length with a step of six inches. There are also impressions of two species of quadrupeds, a row of twelve and another of six pairs of footsteps. The singular species which I describe at page 80, is represented; but I looked in vain for the palmated feet of its posterior extremities.

The impressions upon these fine slabs are beautiful, fully equal to any I have ever seen—the joints, nails, &c., being retained with wonderful fidelity. Upon one of the slabs are two *water marks*, i. e. parallel lines, indicating levels at which the overflowing waters were stationary for a period. Above these lines the slab is spotted with rain-drops, but below them there are none, the face of the slab being abraded to the depth of half an inch. Footmarks of large birds occur below the first level, but none below the second, which appears to be low-water mark. The waters of the ancient sea must have been subject to great fluctuations of level, which seem due to floods rather than tides, for it is difficult to comprehend how the shore or beach could be submerged and dried in the space of a few hours sufficiently to retain footprints. The appearance of these water marks resembles the results produced by still, placid water acting upon muddy margins by the gentlest ripples.

To convey a substantial idea of the manner in which these slabs are traversed by footprints, I subjoin a miniature sketch of one of them, which is about six by three feet in superficial dimensions. It contains eight rows of bird tracks, averaging seven imprints each, generally advancing in pretty direct lines, some parallel to the water's margin, others passing directly into or out of the shallow water. The quadrupeds walked in lines parallel with the water levels. Although these various rows of imprints were made by different individuals, yet they appear to be kindred species and to have been impressed nearly at the same time; yet some were made when the clay was quite soft, and others when quite hard.*

Another of the slabs conforms to the preceding, and contains all its impressions in relief. Upon its upper face are four species of ornithichnites, in rows of five and six each, unsurpassed for beauty. It has one impression of the leaping Batrachian, a small individual to which I have already alluded.

An indescribable interest is imparted by opening the long-sealed volume that contains the record of these extinct animals. The slabs were uncovered and raised under my supervision, and page after page with living inscriptions revealed living truths. There were the characters, fresh as upon the morning when they were impressed, reminding the spectator of the brevity of human antiquity, and of the perishable tenure of human works. On that morning, how long ago none can tell or will ever know, gentle showers watered the earth, an ocean was unruffled, and upon its boundaries primeval beings enjoyed their existence and inscribed their strange eventful history.

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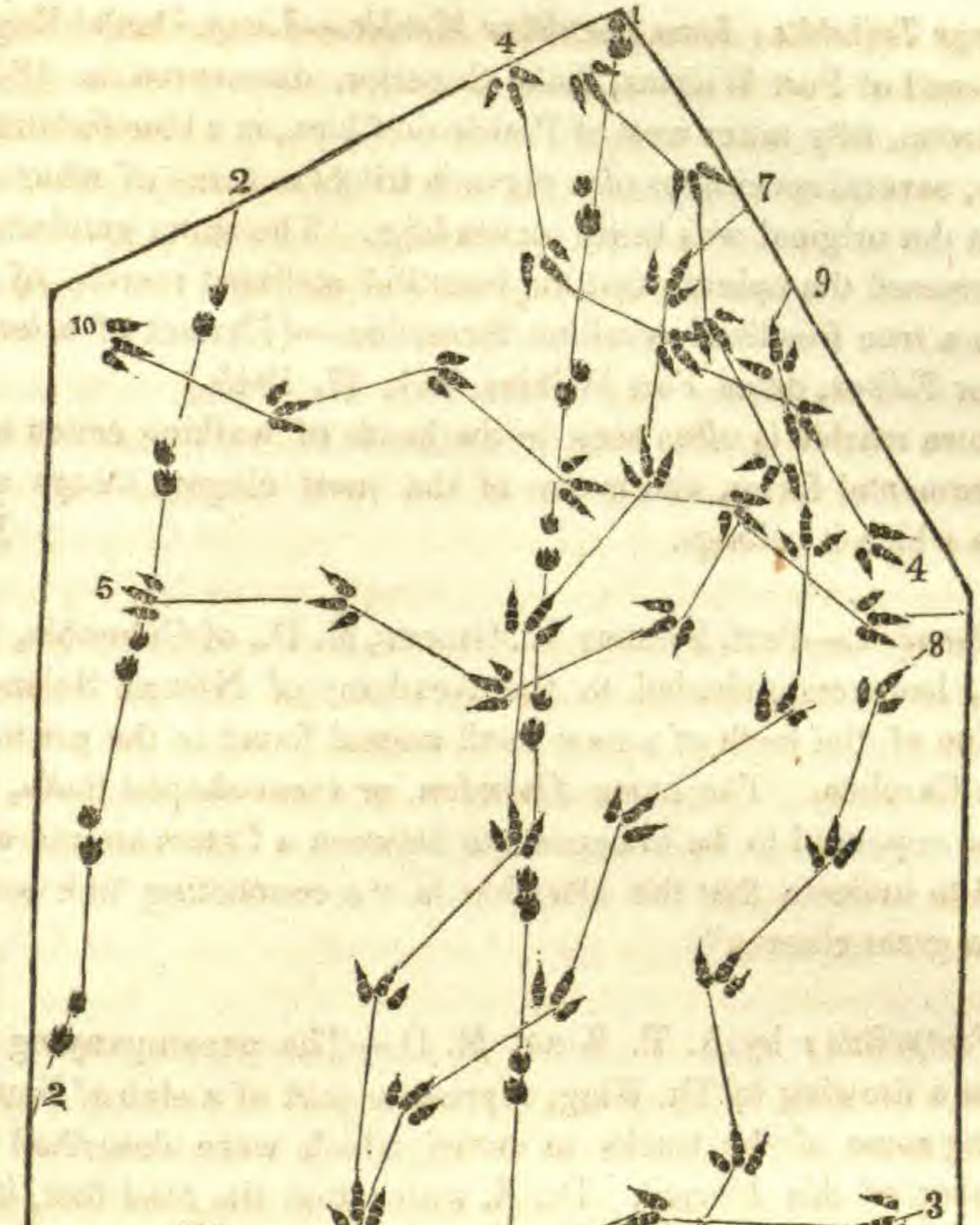
* *Explanation.*—1 to 1, and 2 to 2, footprints of Batrachians. The former is a series of 12 pairs of impressions arranged in a direct line, deeply impressed. The latter were subsequently impressed by a smaller individual. The difference in size between the anterior and posterior feet is great. For a particular description of this species, see this Journal, Vol. XLVIII, p. 158, figs. 1 and 3. 1 to 1 is of the size of fig. 3. 3 to 3, and 4 to 4, are deep imprints of birds whose feet were four or five inches long. The remaining lines vary in size and stride, but have a strong identity. These slabs are somewhat divided by joints, which unite accurately.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9. *Large Trilobite; Iowa Coralline Marble.*—Lieut. Daniel Ruggles, now stationed at Fort Wilkins, Lake Superior, discovered in 1841 at Fort Atkinson, fifty miles west of Prairie du Chien, in a blue fossiliferous limestone, several specimens of a gigantic trilobite, some of which indicated that the original was thirty inches long. The same gentleman in 1840 expressed the opinion that the beautiful stellated marble of Iowa was from a true fossilized coralline formation.—(Extract of a letter to the Senior Editor, dated Fort Wilkins, Feb. 17, 1845.)

The Iowa marble is often seen in the heads of walking canes and in other ornamental forms, and is one of the most elegant things of the family to which it belongs. ED.

10. *Dorudon.*—Prof. ROBERT W. GIBBES, M. D., of Columbia, South Carolina, has communicated to the Academy of Natural Sciences, a description of the teeth of a new fossil animal found in the green sand of South Carolina. The name *Dorudon*, or spear-shaped tooth, refers to a form supposed to be intermediate between a Cetacean and a Saurian, and to indicate that the Dorudon is "a connecting link between these two great classes."

11. *Footprints;* by A. T. KING, M. D.—The accompanying wood cut, from a drawing by Dr. King, represents part of a slab of limestone containing some of the tracks in series, which were described in the last number of this Journal. Dr. K. states that the hind foot, in both the *S. pachydactylum*, (fig. 1,) and *S. leptodactylum*, (2,) is a little larger than the fore foot.*

Dr. K., in a letter to the Editors, describes other impressions which have a very remarkable character; but until further investigated it would be unsafe to consider them footprints. There are eight of these impressions of similar size and shape, forming a continuous series in a bent line; each is of an ovoidal form, 13 inches long, 9 broad, and 3 to 6 deep, and the interval between is 3 feet 6 inches. The impression *before* is deep and ovoidal in the bottom, but behind it is quite shallow or superficial. They occur in slabs of a hard, coarse-grained sandstone, found on the first anticlinal ridge west of Chesnut Ridge, one of the principal ridges of the Alleghany range.

Dr. King proposes to call the hand-shaped tracks, supposed to be Batrachian, (see last number, pp. 348—351,) *Thenaropus heterodactylus.* The generic name is from *θεναρ*, *palm of the hand*, and *πους*, *foot.*

* *References to the diagram.*—1, S. pachydactylum. 2, S. leptodactylum. 3, S. thærodactylum. 4, O. Culbertsonii.


3
Pot
2
Pot
Pot
1
4

12. *Large skeleton of the Zeuglodon of Alabama.*—The Mobile Daily Advertiser of May 23, informs us that Dr. *Albert C. Koch*, well known on account of the gigantic bones of the mastodon* which he discovered in Missouri, has brought to light a skeleton not less colossal of the fossil animal of Alabama, called Basilosaurus by the late Dr. Harlan, and Zeuglodon by Prof. Owen of the Royal College of Surgeons, London. In Vol. XLIV, p. 409 of this Journal, is an account by Mr. S. B. Buckley of a skeleton of this animal, now in Albany, whose entire length is nearly seventy feet. The notice of the recent discovery of Dr. Koch is thus stated in the paper named above:

Its length is *one hundred and four feet;* the solid portions of the vertebra are from fourteen to eighteen inches in length, and from eight to twelve inches in diameter, each averaging seventy-five pounds in weight. Its greatly elongated jaws are armed with not less than forty incisor or cutting teeth, four canine teeth or fangs, and eight molars or grinders. These teeth all fit into each other when the jaw is closed, and it is clear that the animal was carnivorous. The eyes were large and were prominently situated on the forehead, giving the animal the power of keeping a constant and vigorous watch for its prey. The body had members attached resembling paddles or fins, which in proportion to the size of the animal were small, and were doubtless intended to propel the body of this enormous creature through the waters of those large rivers and seas, which it inhabited or frequented. Each of these paddles or fins, is composed of twenty-one bones, which form in union, seven freely articulating joints. The ribs are of a very peculiar shape and exceedingly numerous. They are three times the thickness at the lower that they are at the superior extremity.

The Editor of the Advertiser remarks:—Dr. K. is at present in this city, and has the skeleton of this truly wonderful animal in his charge. The several parts are not yet joined together, but we understand he is willing to arrange and prepare them for exhibition, if there were any probability that he would be remunerated at this period of the year for his labor and expense. Under the circumstances we presume he will take this rare curiosity, which of right belongs to Alabama, to some other place for its first exhibition.

It is evident that these animals were very numerous in those seas, bays, estuaries and lagoons, which once occupied the region where the tertiary and drift formations of Alabama now are.

We trust that an exact and scientific account of this skeleton will be given, and that it will be ascertained whether the bones all belong to one individual.

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* This skeleton has been purchased for the British Museum, at the price of £2,000 sterling, and is now erected in their new Egyptian Hall.

13. *Bones of the extinct gigantic bird of New Zealand, called Moa.* —A quantity of the bones of the Moa has recently (Feb. 1845) arrived in England; the owner requires £200 sterling for them, which the College of Physicians will not give and it was expected that they would be sent to Paris. There is no skull among them, but there is a sternum without a keel, "as might have been anticipated."

Editors' London Correspondence.

14. *Sixth Annual Meeting of the Association of American Geologists.* —The sixth annual session of this Association was held at New Haven, in Connecticut, on the 30th of April, 1845, and the week next succeeding; and was adjourned on Tuesday evening, the 6th of May, to meet again in the city of New York, on the 9th of Sept., 1846, (Wednesday.)

The sessions were held from 9½ A. M. to 1 P. M., and from 2½ to 6 P. M., each day, and the evenings were employed either in session, in public lectures, or soirees at private houses. The place of meeting was the Geological Lecture-room of Yale College, in the same hall with the large cabinet of minerals belonging to the Institution, which was found to be a central and agreeable point for the sessions. The number of members in attendance during the meeting was small compared with the crowds which throng the halls of similar bodies in Europe; but if compared with the small band of votaries who follow subjects of science in this country, the gathering was highly encouraging, and the impression was general among the members present, that the prospects of the Society for future years of extensive usefulness were better than on former occasions. An impression has obtained currency that the objects of this Asssociation are exclusively geological, or directed to those cognate subjects only which have an immediate bearing on that science. This impression has been confirmed, perhaps, by the fact that the published proceedings of the Association, and its volume of Transactions, have shown a great predominance of geological subjects. A constant effort has been made, on the part of the officers of the Association and its individual members, to counteract this impression and to throw open its doors widely for all cultivators of science and the arts who choose to enter. With this view, its constitution reduces the terms of membership to a mere formality of signing that instrument.

The Association ordered its Secretary to prepare and publish as soon as convenient an abstract of the present meeting in a separate form, and we await the appearance of this document before saying anything more particular of the subjects discussed. The reports, in some respects improper, which have appeared in the gazettes were unauthorized by the Association, and they are in no sense responsible for them. The next meeting will be held in the month of September, 1846, in the city of New York.

15. *Comets.*—The comet discovered February 5, 1845, by M. Colla, at Parma in Italy, is the *Southern Comet of December*, 1844, the approximate elements of which are given at p. 403 of Vol. 48 of this Journal. The comet first detected July 7, 1844, by M. Mauvais, at Paris, was observed (after having traversed the southern hemisphere) by M. Argelander, at Bonn, Jan. 31, 1845, and subsequently by many other astronomers.

16. *Second Comet of* 1845.—On the evening of February 25, 1845, a telescopic comet was discovered in *Ursa Major*, by observers at the Collegio Romano. The following parabolic elements of its orbit, derived from observations taken March 7, 18 and 29, at the Observatory of Paris, were communicated by M. FAYE, to the Academy of Sciences, April 14, 1845.

Perihelion passage,	1845, April 21.03748, Paris m. t.	
Longitude of perihelion, - -	192° 33′ 18″·6	m. equin.
" of asc. node, - -	347° 6′ 45″·2	Jan. 1.
Inclination, - - - -	56° 23′ 36″·3	
Perihelion distance, - - -	1·25468.	
Motion, - - - - -	Direct.	

L'Institut, No. 590.

17. *Third Comet of* 1845.—This brilliant comet was discovered in the constellation Perseus, towards the N. E. horizon, about 3 A. M. on Saturday, May 31, 1845, by Mr. Bennett, of the pilot-boat *Aid*, then near Norfolk, Va. On the two subsequent mornings, it was *seen* by persons in various places in this country, but appears to have been first *observed* by Mr. Geo. Bond, of the Observatory at Cambridge, Mass. One witness represented the tail of the comet on the 2nd of June, (between 2 and 3 A. M.,) as very distinct and brilliant, about a degree long; and the nucleus equal in brightness to the star Capella. Some who saw it two or three mornings later represent the tail to have been about ten degrees long. On the morning of the 5th of June, the nucleus appeared as bright as the planet Jupiter. The comet has been visible, (for the few last days in the telescope only,) down to the 27th of June, but will soon be lost in the twilight. Its position, from the first discovery, has been rather unfavorable for observation, on account of its nearness to the horizon.

The following sets of approximate elements were published on the 13th of June, the one by Prof Peirce, of Cambridge, from observations there taken by Messrs. Bond; the other by Messrs. Kendall and Downes, of Philadelphia, from observations of June 4, 8 and 11, made at the High School Observatory in that city. These elements do not agree with those of any comet on record.

	P.	K. & D.
Perihelion passage,	1845, June 5·542, Gr. m. t.	June 5·394902, Ber. m. t.
Long. of perihelion,	263° 40′	265° 3′ 53″ } m. equin.
" asc. node,	339° 52′	341° 16′ 6″ } June 8.
Inclination,	49° 0′	49° 37′ 4″
Perihelion distance,	0·4002	0·397809
Motion,	Retrograde.	Retrograde.

18. *The Earl of Rosse's Leviathan Telescope.*—In Vol. XLVI, p. 208 of this Journal, we gave a condensed account of Lord Rosse's great reflecting telescope, from papers furnished by our friend, Mr. John Taylor of Liverpool. From the same gentleman we derive the means* of making the following statement on the authority of Sir James South, of the Royal Observatory, Kensington.

Last September, Sir James announced, through the Times, that the great telescope had been directed to the heavens and with the happiest results. The great speculum, however, had then been only approximately polished, and was ascertained to possess very nearly the proper focal distance. Having been taken out and reground and polished, it was (March 4, 1845) reinstated in the tube. Although in our former notice we gave some important particulars regarding this instrument, we now insert Sir James South's description entire, although at the risk of some repetition.

Description.—"The diameter of the large speculum is six feet, its thickness five inches and a half, its weight three tons and three quarters, and its composition 126 parts of copper to 57½ parts of tin; its focal length is 54 feet—the tube is of deal; its lower part, that in which the speculum is placed, is a cube of eight feet; the circular part of the tube is, at its centre, seven feet and a half in diameter, and its extremities six feet and a half. The telescope lies between two stone walls, about 71 feet from north to south, about 50 feet high, and about 23 feet asunder. These walls are, as nearly as possible, parallel with the meridian.

"In the interior face of the eastern wall a very strong iron arc, of about 43 feet radius, is firmly fixed, provided, however, with adjustments, whereby its surface facing the telescope may be set very accurately in the plane of the meridian—a matter of the greatest importance, seeing that by the contact with it of rollers attached to one extremity of a quadrangular bar, which slides through a metal box fixed to the under part of the telescope tube, a few feet from the object end of the latter, whilst its other extremity remains free, the position of the telescope in the meridian is secured, or any deviation from it easily determined, for on this bar lines are drawn, the interval between any ad-

* From the Times, and the Illustrated London News.

joining two of which corresponds to one minute of time at the equator. The tube and speculum, including the bed on which the latter rests, weigh about 15 tons.

"The telescope rests on an universal joint, placed on masonry about six feet below the ground, and is elevated or depressed by a chain and windlass; and, although it weighs about 15 tons, the instrument is raised by two men with great facility. Of course, it is counterpoised in every direction.

"At present it can be used only between 14 degrees of southern altitude and the zenith, but when completed its range will embrace an arc between 10 degrees of altitude toward the south, and 47 degrees north; so that all objects between the pole and 27 degrees south of the equator will be observable with it; whilst in the equator any object can be viewed with it about forty minutes of time on either side of the meridian.

"The observer, when at work, stands in one of four galleries, the three highest of which are drawn out from the western wall, whilst the fourth, or lowest, has for its base an elevating platform, along the horizontal surface of which a gallery slides from wall to wall by machinery within the observer's reach, but which a child may work.

"When the telescope is about half an hour east of the meridian, the galleries hanging over the gap between the walls present to a spectator below an appearance somewhat dangerous; yet the observer, with common prudence, is as safe as on the ground, and each of the galleries can be drawn from the wall of the telescope's side so readily, that the observer needs no one else to move it for him.

"The telescope, lying at its least altitude can be raised to the zenith by the two men at the windlass in six minutes; and so manageable is the enormous mass, that give me the right ascension and declination of any celestial object between these points, and I will have the object in the field of the telescope within eight minutes from the first attempt to raise it.

"When the observer has found the object; he must at present follow it by rack-work within its reach. As yet it has no equatorial motion, but it very shortly will have it, and at no very distant day clock-work will be connected with it, when the observer, if I mistake not, will whilst observing, be almost as comfortable as if he were reading at a desk by his fireside."

Observations.—The night of the 5th of March was very clear, and the sidereal pictures were glorious. Many nebulæ were for the first time since their creation, seen as groups or clusters of stars.

The ring nebula in the Canes venatici, the 51st of Messier's catalogue, was resolved into stars with a magnifying power of 548, and the 94th of Messier into a large globular cluster of stars.

The power of this telescope in resolving nebulæ, hitherto considered irresolvable, was extremely gratifying.

Perfection of figure in a telescope, must be tested, not by nebulæ, but its performance on a star of the first magnitude.

"If it will, under high power, show the star round and free from optical appendages," it will not only show the nebulæ well, but any celestial object as it ought to be. "Regulus on the 11th, being near the meridian, I placed the six feet telescope on it, and with the entire aperture and a magnifying power of 800, I saw (says Sir James) with inexpressible delight, the star free from wings, tail or optical appendages; not indeed a planetary disk, but as a round image resembling voltaic light between charcoal points; the telescope, although in the open air, and the wind blowing rather fresh, was firm as a rock."

"On subsequent nights, observations of other nebulæ, amounting to some thirty or more, removed most of them from the list of nebulæ, where they had long figured, to that of clusters; whilst some of these latter, but more especially 5 Messier, exhibited a sidereal picture in the telescope such as man before had never seen, and which for its magnificence baffles all description.

"Of the moon a few words must suffice. Its appearance in my large achromatic, of twelve inches aperture, is known to hundreds of your readers; let them imagine that with it they look *at* the moon, whilst with Lord Rosse's six feet they look *into* it, and they will not form a very erroneous opinion of the performance of the great telescope.

"On the 15th of March, when the moon was seven days and a half old, I never saw her unillumined disk so beautifully nor her mountains so temptingly measurable. On my first looking into the telescope, a star of about the seventh magnitude was some minutes of a degree distant from the moon's dark limb. Seeing that its occultation by the moon was inevitable, as it was the first occultation which had been observed with that telescope, I was anxious that it should be observed by its noble maker; and very much do I regret that through kindness towards me he would not accede to my wish; for the star, instead of disappearing the moment the moon's edge came in contact with it, apparently glided on the moon's dark face, as if it had been seen through a transparent moon, or as if the star were between me and the moon. It remained on the moon's disk nearly two seconds of time, and then instantly disappeared, at 10*h.* 9*m.* 59·72*s.* sidereal time. I have seen this apparent projection of a star on the moon's face several times, but from the great brilliancy of the star this was the most beautiful I ever saw. The cause of this phenomenon is involved in impenetrable mystery."

Sir James South describes the Newtonian telescope and the improvement of Le Maire, as follows.

"Thus, then, the difficulty of constructing a Newtonian telescope of dimensions never before contemplated is completely overcome; but to render the part on which I am about to enter more generally intelligible, let me say, that the Newtonian telescope is composed of a large concave speculum, of a small flat speculum, and of an eye-glass. The large concave speculum lies in the closed end of the tube at right angles to the tube's axis. The small flat speculum is placed near the open end of the tube in its centre, but at half right angles with the tube; whilst the eye-glass (a hole for the purpose being pierced in the tube's side) is fixed opposite the centre of the flat speculum. The rays from the object to which the telescope is directed, fall on the large concave speculum, are reflected from it into the focus, in which the image of the object is formed; this image falls on the small flat speculum, and is reflected from it to the eye-glass, by which it becomes magnified, and enters the observer's eye. But only a part of the light which falls on the large concave speculum is reflected on the small speculum; and again, only a part of that which falls from the large speculum on the small one is reflected from the latter to the eye-glass. Newton, to avoid this loss of light by the second reflection, proposed the substitution of a glass prism for the small flat speculum; but from some difficulties which have attended its use, it has (perhaps too hastily) been laid aside.

"In 1728 Le Maire presented to the Académie des Sciences the plan of a reflecting telescope, in which the use of the small flat speculum was suppressed; for by giving the large concave speculum a little inclination, he threw the image formed in its focus near to one side of the tube, where an eye-glass magnifying it, the observer viewed it, his back at the time being turned towards the object in the heavens; thus the light lost in the Newtonian telescope by the second reflection was saved."

Lord Rosse has determined to give to the great telescope the Lemairan form; but what will then be its power it is not easy to divine;—"what nebulæ will it resolve into stars; in what nebulæ will it not find stars; how many satellites of Saturn will it show us; how many will it indicate as appertaining to Uranus; how many nebulæ never yet seen by mortal eye will it present to us; what spots will it show us on the various planets; will it tell us what causes the variable brightness of many of the fixed stars; will it give us any information as to the constitution of the planetary nebulæ; will it exhibit to us any satellites encircling them; will it tell us why the satellites of Jupiter, which generally pass over Jupiter's face as discs nearly of white light, sometimes traverse it as black patches; will it add to our knowledge of the physical construction of nebulous stars; of that mysterious class of bodies which surround some stars, called, for want of a better name, 'photospheres;' will it show the annular nebula of Lyra merely as a brilliant luminous ring; or will it exhibit it as thousands of stars arranged in all the symmetry of an ellipse; will it enable us to comprehend the hitherto incomprehensible nature and origin of the light of the great nebula of Orion; will it give us in easily appreciable quantity the parallax of some of the fixed stars, or will it make sensible to us the parallax of the nebulæ themselves; finally, having presented to us original portraits of the moon and of the sidereal heavens, such as man has never dared even to anticipate, will it by daguerreotypic aid administer to us copies founded upon truth, and enable astronomers of future ages to compare the moon and heavens as they then may be, with the moon and heavens as they were? Some of these questions will be answered affirmatively, others negatively, and that, too, very shortly; for the noble maker of the noblest instrument ever formed by man 'has cast his bread upon the waters, and will, with God's blessing, find it before many days.'"

"As it is interesting to trace the progress of human industry and intelligence, I will say a few words, indicating their effects as far as concerns the Newtonian reflecting telescope. It was discovered by the head and made by the hands of Sir Isaac Newton in 1671; its large speculum was two inches and three tenths in diameter; its focal length was about 6 inches, and magnified 38 times; it is in the possession of the Royal Society. I regret to say it is in a most dilapidated condition, and its eye-glass is lost.

"The next of any importance was made by Hadley in 1723; its large speculum's diameter was about 6 inches; its focal length about 63 inches; it magnified 230 times; in performance it equalled the great Huygherian refracting telescope, of 6 inches diameter and 123 feet focus. He gave it to the Royal Society. Its metal is ruined, and its tube, its stand, and others of its appurtenances are lost.

"Short succeeded Hadley. The figure of his metals was very good, but their *composition* was bad and very liable to tarnish. Still he greatly excelled all who had gone before him, and, that posterity might not be aided in their attempts to make reflecting telescopes by any knowledge he had acquired, he ordered, before his death, all his tools to be destroyed.

"Next to Short came Herschel; his metals were of a very inferior composition; in others' hands his telescopes did but little, but in his own they raised for him an imperishable name.

"Watson followed Herschel. His metals, in composition, figure and polish, were exquisitely perfect; his largest Newtonian did not exceed 9 inches aperture; with large ones he never grappled, but for such as he did make I doubt if he was ever equalled, and am sure he never was surpassed.

"Cotemporary with Watson was Tulley; his telescopes were superior to Short's, but certainly inferior to Watson's.

"Ramage, about 1820, constructed telescopes of 15 inches diameter and 25 feet focal length—they were Lemairans. One of them was many years in the court-yard of the Royal Observatory of Greenwich, where its performance was much taunted. At the request of my late friend, Dr. Wollaston, I examined it whilst it was there. Sir J. Herschel accompanied me, and with an aperture beyond 7 inches it was good for nothing. It has, I am told, recently been purchased for the Observatory of Glasgow.

"From the late Earl of Stanhope's endeavors, all who knew him expected much,—for some 30 years before his decease he occupied himself very much in endeavoring to produce large reflecting telescopes. Although, however, he was a sound mathematician, and a most powerful mechanic, his failure was complete. After his decease, his manuscripts on scientific subjects having become the property of the Royal Institution, I thought that even the errors of such a man must be instructive; I have therefore recently waded through all that relate to the manufacture of reflecting telescopes, and I think there is scarcely amongst them a single hint which is worth remembering.

"Having dwelt so long on the telescope itself, I have only space to say that the mechanism for using it is worthy of the telescope and of him who made it. All appertaining to the telescope, except its principle, is original. The only master who might have left something like a copy for imitation was Sir W. Herschel—for any information, however, which the Earl of Rosse, or any one else, except his son, (who has for nearly a quarter of a century kept it to himself,) has derived from Sir W. Herschel's experience in making large telescopes, Sir William might as well never have been born. Information which might have been in the highest degree important if communicated to the world at a proper season, can now, thanks to Providence for having given us the Earl of Rosse, who is openness itself, (for his own fame, perhaps, even to a fault,) be easily dispensed with; whilst a hint is given to those who, like Short and Sir W. Herschel, kept their secrets even unto death, that others will succeed them, the success of whose energies, industry and talents will most assuredly eclipse theirs; and who, by following conduct as generous as theirs was selfish, will be regarded as benefactors to mankind.

"Far be it from me to say a disrespectful word of the late Sir W. Herschel. Whilst he lived, I loved him; now dead, I venerate his memory—nay, I respect the very ground he worked on; his integrity as a man and as an observer I implicitly confide in. I cannot, however, refrain from saying, that if it be true that the 6th and 7th satellites of Saturn were not discovered by the 40 feet telescope made by him at the expense of George III, as from his own words, found in the *Philo-*

sophical Transactions, I stated they were, in a lecture given at the Royal Institution, on Lord Rosse's telescope, in May, 1843, I must, however painful to me to do so, regard the remains of that telescope, which I visited not long ago, as a monument of failure. I therefore entreat his son, seeing that his father's veracity is impugned by doubts which have been recently and publicly expressed by one of the first astronomers of Europe, to give to the world every information on the subject which his father's manuscripts supply; assuring him, however, that till this be done by him, and till *it* demonstrates the contrary, there shall be at least one of his father's friends who believes that by Sir W. Herschel's pen plain or naked truth was never violated.

19. *Notices drawn from a letter of our London Correspondent, dated June* 10, 1845.

Silicification.—A memoir on the microscopical examination of the chalk and flint of the South East of England, illustrated by drawings and several microscopes, with fossil and recent subjects, was read before the Geological Society by Dr. Mantell, Wednesday, June 4. It described the silicification of organic bodies, and particular reference was made to Mr. Dana's remarks on pseudomorphism in the April No. of this Journal, Vol. XLVIII, No. 2. We are evidently approaching a period when all the siliceous petrifactions, even those of gigantic trees and extensive forests, will be explained.

Sigillaria and Stigmariæ.—The identity of these fossil trees of the coal formation, as described in Dr. Mantell's Medals of the Creation, has been fully confirmed. Dr. Buckland read before the Geological Society a letter from Mr. Binney, the discoverer of the stem and roots figured in the Medals—confirming his previous account, and leaving no doubt that the Stigmariæ are the roots of the Sigillaria. "But they are still very marvellous fossils, for we have no roots with which they are at all analogous; the regular quincunx arrangement of the tubercles and the articulation of the fibrils differ from any recent known thing."

Plumbago formed by pressure.—This subject was brought forward at the same meeting. "The only good mine of graphite (black lead) is exhausted of its best kind; and to meet the demand for pencils, now greater than ever, they search over the heaps of rejected ore formerly thrown aside." "This rubble is reduced to an impalpable powder and then subjected to great pressure in moulds, and the result has been the most pure and beautiful graphite; and the artificial mineral is now cut up for our best pencils."

Crosse's Accari.—"These insects, which possess the privilege of living, like demons, where all other beings would perish, have been found in the strongest *liquid volatile ammonia*, without any galvanic agency."

"Mr. Wilkes has repeated Crosse's experiments on the production of Accari, and appears to have used every precaution for excluding and killing the ova of any animals, and yet these Accari appeared. But I cannot think that any physiologist will for a moment admit that the insects were produced by galvanic action, or even more readily developed by it; although the latter is not impossible."

Atmospheric Railroads.—A road of this description is about to be laid down from Bristol, England, to Partis Head. It would appear, therefore, that confidence is reposed in this new power of progression in travelling.

20. *Columbite.*—In a series of chemical examinations of the several varieties of Columbite from different localities, Prof. H. Rose has obtained the following for the composition of a specimen from this country. Columbic acid, 79·62; protoxyd of iron, 16·37; protoxyd of manganese, 4·44; impure oxyd of copper, 0·06; oxyd of tin, 0·47; with a trace of lime, = 100·96. Specific gravity of the specimen, 5·708. Streak dull reddish brown. The particular locality was not known. Specimens from Middletown, Conn., afforded a specific gravity, when reduced to powder, varying from 5·475—5·495. The Bodenmais Columbite, in crystallized specimens, afforded the specific gravity 6·390, and the composition columbic acid, 81·34; protoxyd of iron, 13·89; protoxyd of manganese, 3·77; impure oxyd of copper, 0.10; oxyd of tin, 0·19; traces of lime, = 99.29. In other specimens the specific gravity varied from 5·6996 to 6·078.

21. *Gray Antimony.*—Prof. O. P. Hubbard reports a locality of this mineral in Lyme near Dartmouth College. Loose specimens were found, as mentioned in Jackson's Report on the Geology of New Hampshire, some two years since. It is now found in place, in crystals three and four inches long, in veins of quartz intersecting granite.

22. *Postage of Printed Sheets in England.*—We had occasion to send to our correspondent thirty three pages of printed proof—one page over two sheets. For this, he remarks that he paid 11*s.* 6*d.* I wish, he observes, to call your attention to it, as it might be well to notice in your Journal, that the British Post Office charges for all printed papers or pamphlets; and English savans are often put to great expense from foreigners not being aware of this circumstance.

ERRATA.

Page 183, l. 18 from bottom, for "Palagia," read "Falagria;" l. 16 fr. bot. for "flavicernis," read "flavicornis." P. 185, l. 17 fr. bot. for "æreola," read "æneola;" l. 11 fr. bot. for "Athoiis," read "Athous;" l. 10 fr. bot. for "æreolus," read "æneolus."

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Art. I.—*The Coast Survey of the United States.*

The interest which the readers of this Journal must have always felt in the condition and progress of the United States coast survey, has been very much (and naturally so) increased by the appointment of Dr. Bache to the office of superintendent. The work is now exclusively under American control, and though science, 'as broad and general as the casing air,' recognizes no invidious distinction of age or climate, yet reproaches which it is not worth while to remember, still less to repeat, have forced this consideration upon the notice of all those who feel a just pride in the scientific reputation of the country.

Among the readers of this Journal the present superintendent numbers many personal friends, and many others, who, governed by his reputation, gave the influence of their names to secure his nomination for his present responsible office, after Mr. Hassler's death. To these gentlemen, the successful prosecution of the coast survey has become a matter of more than ordinary interest. They may be said to have assumed a responsibility with regard to it. They will be glad then to learn something of its scientific details.

The fundamental principles of a geodetic survey, are of too elementary a character to be treated in this place. Neither will the reader look here for an abstract of the last report, showing the space occupied, and the amount of labor performed. Both of these topics have been recently handled with great clearness and elegance, in a popular form, by a writer in the "Biblical

Repertory and Princeton Review." The object of the present article is to make known some of the new methods of observation and reduction which Dr. Bache has himself introduced into the survey, and certainly it cannot but be regarded as a favorable sign of the times, that the means are supplied for writing such a paper; that openness and freedom of communication are substituted for secrecy, and the habitual mistrust, to say nothing worse, which mystery always implies.

It is only necessary to remark before entering at once upon the subject, that a slight divisional arrangement has been adopted for convenience, and that having to speak of such changes only as are due to Dr. Bache, a frequent reference to his name is unavoidable.

In the determination of *latitudes* the superintendent has adopted a method in accordance with the established facts of observation, and with the extent of his means and authority. It is undoubtedly most desirable that the work should finally rest for authority in its astronomical determinations upon two permanent and well endowed observatories in distant parts of the country. Such was the project of Mr. Hassler, and it was owing perhaps to the hope that it might be realized, that up to the time of his death, no regular astronomical observations had been made at any of the stations of the primary triangulation, since leaving Weasel. During this interval, however, (it would be unjust to omit the mention of it,) some voluntary observations have been contributed by Mr. Edmund Blunt, one of the two principal assistants.

But the prospect of obtaining the efficient support of a well conducted observatory in the southern section of the Union is distant, notwithstanding the noble efforts directed to that object in Alabama. In the mean time it must be considered the part of prudence, as well as fidelity, to accomplish all that is possible, and the superintendent has undertaken this in such a manner that the results will form an interesting contribution to physical science, independently of their value in settling individual positions. Last summer, observations for the latitude were made at six stations of the survey, four at the north and two at the south, and this season the same observations will be continued, not only at the stations of the new primary triangulation, but also to supply the deficiencies of the old work. The principle which demands these frequent determinations, is the necessity for reduction to a central point, arising from the irregularities of gravitation, occasioned by the variations in form and density of the materials composing the earth's crust. The theory, though familiar to the student of physics, requires to be stated in this connection. If in consequence of the proximity of a mountain the plumb line be drawn from the position it would otherwise maintain, it is evident that the point of the heavens which corresponds to the zenith of a station, as determined by astronomical observations, would not be the same as if the mountain did not exist. The apparent direction of gravity being different, the apparent horizontal line is also changed. The length of the radius of curvature of the meridian undergoes a corresponding alteration, and the angle which measures the elevation of the pole, has its vertex, not at the centre of the earth, but at a point at a distance from the centre, depending upon the apparent line of direction of gravity.

The existence of such an attraction is a valuable part of knowledge, proved by accurate practical investigation. Observations were made in the year 1774, by Dr. Maskelyne, for ascertaining the attraction of the mountain Schehallien. The points to be compared were connected by measurement, and determined astronomically. Two results differed 11″·7! from each other, which great discrepancy is to be attributed to the sum of the deflections of the plumb line on the opposite sides of the mountain.

Baron de Zach, also, in 1810 showed that the attraction of the Mimet mountains, near Marseilles, was appreciable. It appears to have produced an error of 1″.98 in the latitude. M. Arago condemns the repeating circle used by Zach, and Mr. Airy observes that the stars were all on the same side of the zenith, a change therefore in the constant error of the instrument would produce an error in the result. Without attaching any importance to the minute accuracy of the determination, however, it sufficiently illustrates the principle treated. The same facts are attested by the observations of Boscowich and Beccaria in Italy.

It might be expected that the pendulum, a more delicate means of experiment, would also indicate by its vibrations the existence of these irregularities. Such is indeed the case. It is now well known that the attraction peculiar to the locality, does in frequent instances affect the mean force of gravity; and it is owing to the gravitating force, not only of the base on which the pendulum stands, but also of the adjacent materials, that it is necessary to modify the rule, which would obtain, were the earth of an uniform density, viz. that the reductions from one level to another are strictly proportioned to the squares of their respective distances from the earth's centre.

Instances appear of defect and excess in the vibrations of the pendulum, of the former at Maranham and Trinidad, and of the latter at Spitzbergen and Ascension, where the experiments were conducted with such extreme precision as to prove conclusively that the irregularities are not to be charged to the experiments themselves, but to the natural phenomena which it is their purpose to investigate.

But to return to astronomical indications. Observations show that the attraction of masses comparatively small, is sensible. The discrepancies noted in comparing different parts of the same arc may be cited. At Arbury Hill there was found a difference of 5″, not to be accounted for upon any supposition of the earth's figure. There is also an unexplained disturbance at Dodagoontah, on the great Indian arc, to nearly the same amount. In inferring the latitude of one place from the observed latitude of another not on the same meridian, through the medium of a geodetic measure, results are obtained differing from observation more than could happen in the use of the astronomical instruments, or of the geodetic measurements, without the most unreasonable neglect. Thus the latitude of Turin deduced from that of Milan differs from the observed latitude by 8″·9, that of Venice from the same origin 9″·5, and that of Rimini 27″·4. The same results appear upon the journals of the coast survey. The latitudes of New York and Boston do not agree together. Boston, Cape Henlopen, and New York differ from Philadelphia, and the various stations about the city of New York, when transferred to a central point, are all at variance with observation.

Finally, the great disagreement, it may be observed, between various geometers as to the ratio of eccentricity, is attributed by some writers, in a measure to erroneous latitudes, occasioned by deviations of the level.

These facts, and the theory which flows from them, prove the importance of the rule of observation adopted by the superintendent. He not only arrives at the most correct determination of latitude compatible with the means allowed him, but is rendering valuable aid towards the thorough investigation of a very interesting question, a question intimately connected with his future discussions of the figure of the earth.

In connection with this subject, it may be mentioned that it is the design of Dr. Bache to employ observations of transits over the prime vertical for the determination of latitudes, as soon as the requisite instruments can be supplied. During the preceding winter the latitude of Cambridge observatory was determined in this manner, with such admirable coincidence in the results as to leave nothing to be desired. The observers were, Major Graham of the Topographical Engineers, Mr. Wm. C. Bond, the director of the observatory, and Mr. G. P. Bond, his son. The observations were reduced by Prof. Peirce, and will appear in the Transactions of the American Academy. They have also been communicated by Prof. Peirce to the office of the coast survey.

Astronomical azimuths require also frequent determinations in order to ensure accuracy, and to save the ungrateful labor of retrospective calculation. With regard to this important element in geodesy it is theoretically true, that when one azimuth has been defined, others can be deduced from it by simple calculation in the progress from station to station. But repeated measures for verification are indispensable to avoid error, and to escape the trouble of reoccupying old stations. During the preceding season the azimuthal bearing was ascertained, independently, for six of the primary stations, four at the north and two at the south.

Of the two heavenly bodies most commonly used in this operation, Mr. Hassler preferred the sun, but Dr. Bache has employed for the first time on the work, the elongations of Polaris, in both its eastern and western digressions. His objection to the sun is the exposure of the instrument, which cannot fail to be affected by the heat of this luminary.

A distinguished astronomer, it may be remarked, directed the English surveyors never to use the sun for any geodetic determination. The prominent advantage in using Polaris, is the opportunity it affords for a very careful and deliberate observation. At the time of elongation, when the change of altitude is most rapid, the movement in azimuth is nothing; there is ample time therefore to repeat the measurement until satisfied with its exactness. The observations are continued for several successive days. The necessity, as it is generally considered, of using distant night signals for this mode of determining azimuths, is avoided. The superintendent has adopted the suggestion of the Astronomer Royal at Greenwich, who proposed referring the points of greatest elongation of circumpolar stars, to marks in the horizon, by perpendicular lines demitted by means of an altitude and azimuth circle. Elongation signals are established about two miles distant, consisting of a delicate wand by day, and a lamp by night, the latter of which is seen through a small hole perforated in a board set up for the purpose.

This method is peculiarly applicable to a large theodolite with a micrometer eye-piece,—first the position of the star is observed and then the signal with the micrometer, and so on alternately for ten minutes before, and ten after elongation. Many observations are accumulated in one day, care being taken to ensure the steadiness of the instrument and the correct leveling of the axis. Measures were made by the reflected, as well as the direct image of the star, but this precaution was found to be superfluous. The elongation signals are observed in turn with all the other signals, and the probable error of the results is found to be less than the best on record in the French survey when the repeating circle was employed. The French used Polaris near elongation, but not both elongations. Distant night signals have been attempted with general success, and for this purpose a lens was borrowed from Mr. Lewis. Where these were set up, the arc of distance from Polaris to the signal, which is the measure of the diedral angle formed by the two vertical planes of the signal and star, could be taken directly, and this, it is believed, was the method most in favor in the recent French triangulation.

Concerning the observation of *terrestrial angles and the use of the large theodolite*, Mr. Hassler has very justly said, that, "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 defects in the instrument will always be prudent. It becomes, therefore, the duty of an observer to combine and invent, upon theoretical principles, methods of systematic observations, by which the influence of any error of his instruments may be neutralized, either by direct means, or more generally, and much more easily, by compensation. 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 observations."

That portion of geomorphy which comprises the measurement of terrestrial angles of the first order, demands the nicest exactitude, because it embraces the consideration of the earth's figure, and because the celestial observations of a geodetic survey are directly connected with it. That observations should be numerous, as one mode of compensation, is evident.

Another question arises as to the best circumstances in observing, and the number necessary to secure a very small probable error. This question the superintendent has now resolved, by an application of the method of least squares for the first time on the survey. Its general and successful use by Prof. Lloyd, in the magnetic survey of Great Britain, may be seen in the eighth Report of the British Association. There is reason to think that the method adopted by some engineers of selecting for observation those times only which appear the most favorable in all their minutest circumstances, does not lead to the best results. Swanderg in Lapland may be here particularly referred to, whose observations, very few in proportion to the time occupied, do not appear to have commanded the highest confidence. Now the mode introduced by Dr. Bache has been to determine, by repeated trials, and by a rigid application of the method of least squares, what is the number of observations which, taken under circumstances such as are ordinarily favorable, will reduce the probable error within the limits of deviation of the instrument, and of the observer. That number, thus established, becomes the rule of conduct. The application of this method has increased not only the economy, (a very important consideration, for economy is progress,) but the rapidity of the work in a striking manner, as may be seen from a comparison of the field work of last year with that of any previous year; and, what is most to be regarded, it secures a greater accuracy in the compensation of errors. Of six triangles the greatest difference from 180°, after allowing for the spherical excess, was 0″·6 of a second of space, that is 0″·2 to an angle, and from this the difference descended to nothing.

The nicety of this result rivals both the English and French surveys. It is not necessary to carry comparisons (which may appear invidious) any farther at present; but they need not be shunned, whatever the source or standard by which they are challenged. It is only necessary to add that the calculations were not made by Dr. Bache himself.

This subject leads to the mention of the formulæ used upon the survey for the calculation of L. M. Z. which depend upon the figure of the earth. The value of e^2, the expression by which the ellipticity enters into these equations, has been variously decided by the most distinguished geometers, and has resulted differently from the comparison of different meridional measurements; from experiments with the pendulum by different observers, and from calculations of it from the moon's motion by La Place and Buckhardt. The history of these facts will be familiar to the reader. Among the comparatively modern determinations, the linear measure of Mason and Dixon in 1764 has given a result in one extreme, and the magnificent triangulation of Méchain et Delambre in the other. This is precisely one of those questions in which the purely practical depends upon the purely theoretical, and that of the highest order. The direction hitherto taken by the main triangulation of the coast survey does not enable it to supply the measurement of an arc of meridian, that is, an element for deducing the figure of the earth satisfactorily. But it is now approaching this point. The triangulation from Nantucket, (which will be one of the points of the first order during the present season,) to Portland, will qualify the survey to take its place in this respect also amongst the permanent scientific works of the world.

From the head to the mouth of the Chesapeake will be formed another series, favorably situated for this purpose, and here the line of Mason and Dixon will be included and its accuracy tested. The tables for the reduction of triangles, and for projection, were first calculated by Mr. Hassler in 1818, but in 1834 he found it necessary to repeat all the calculations,—the knowledge of the dimensions and figure of the earth having been much improved and more strictly defined. Since then, however, has appeared the determination of Bessel, founded upon a comparison of all the authentic measures, to each of which is assigned its just weight as determined by the theory of probabilities, or the method of least squares. This is the result accepted by the scientific world, and which it is *now* imperative to employ. Not only are new tables to be calculated for future use, but all the old triangles are to be recomputed to the original base. The accumulation of small errors renders this course obligatory, and indeed indispensable. But the values in the new tables will be affected not so much by the change of ellipticity, as by a proper return to the *legal* ratio of the metre to the toise. The toise was the standard of linear measure in France, employed in the measurement of the French arc between Dunkirk and Barcelona, and virtually also in its continuation by MM. Biot and Arago, by which the parallels of Paris and Formentera were connected. Virtually it is said, because the legal ratio of the metre was preserved. The definition of the metre as the millionth part of the quadrant of the meridian, having been shown by the laborious computations of Colonel Puissant to be imaginary, it only remains to adopt and preserve the value given it by the law of 1799, and subsequently confirmed by the law of 1837.

It might be argued, if argument were applicable to the case, that the attempt to assign to the metre a theoretic value would defeat itself,—for neither geodesic operations, nor the present methods of calculation, could settle its value with such certainty but that future geometers might find occasion to modify numbers which now appear to be the most established. It may be said, further, that when the metre was adopted by the commission consisting of Borda, Lagrange, La Place, &c., it was done with a limitation subsequently confirmed; and this limitation, being a very close approximation to the truth, may be regarded as definitive. Whatever may be the future progress of science, it can never be convenient to alter it; but it is only requisite to have a distinct idea of what it represents. Upon this subject Mr. Hassler assumed a different, and as it has been pronounced by very high authority, a novel idea. When the standard metres were distributed by the committee of weights and measures, Mr. Tralles, the deputy from Switzerland, obtained an extra one, perfectly authenticated, which he presented to Mr. Hassler. The latter, having in his possession five brass and three iron metres, and several standard toises, including those of Canivet and Lenoir, instituted a series of comparisons with the comparateur of Troughton, which can never fail to command the most sincere admiration for the philosophic accuracy and elegance of their execution, but by means of which he arrived at a ratio independent and exclusive. His purpose was to establish an authentic standard with bars of recognized authority. Had the subject required further research, no one could hesitate to admit his results, as every one must admire the zeal, learning, and fidelity he displayed. But the legal ratio is in fact the only one admissible. This is an evident truth. When the metre ceased to be considered the ten-millionth part of the quadrant of the meridian, it became equally with the toise a mere iron bar, having no other value than that assigned it by law; and that value was a permanent one, which no individual experiments could be permitted to change.

On this point there can be no higher authority than that of M. Bessel, which it may be well to quote. "Mr. Hassler deduced from several comparisons the value of the metre in parts of the toise. But this I consider as not allowable, for the ratio between the two is determined by law, by which the metre has received its true definition. If certain copies of these metres do not agree together, *it shows that the law is not exactly fulfilled by them;* and as it is much more difficult to transfer to another metallic bar 443·296 lines of the toise than the whole length of the toise, the value of the metre is a circuitous and unprofitable way, as long as the toise is as easily obtained as it was at the time of the construction of the metre."

Mr. Hassler's ratio differed from the legal ratio (443·296) by −0·015 lines of the toise, an amount quite serious when multiplied by frequent repetitions.

At the primary stations last year Dr. Bache made use for the first time of vertical angles for determining differences of heights. For this the triangulation at the north offers a fine field; but the features of the coast at the south will preclude its frequent application there. This method will be continued. The effect of refraction near the surface may be investigated by a series of observations, and these angles can be measured at a time of day when it would be impracticable to observe the horizontal angles.

A new system of *magnetic observations* has been introduced into the coast survey. The declination of the magnetic needle, which is of indispensable practical utility, is to be carefully ascertained at every important station of the work. It is needless to say, however much the subject may have been neglected hitherto, that without it any map or chart would disgrace the office from which it issued. To this the superintendent has added other results without increase of expense. There is no branch of physical science which, at present, engages more active attention than magnetism. The magnetic surveys conducted and observations established by the government of Great Britain at home, and all over the world, are worthy of the munificent support that nation has always given to science, and the diffusion of sound knowledge. It is a matter of humble pride that something has been done also in this country, at the magnetic observatory of Cambridge under the direction of Professor Lovering and Mr. Bond, and still more at the observatory of Girard College under the direction of Dr. Bache. The publication of the latter observations, with the curves of diurnal and monthly variation, by the government of the United States, enables this country to add a respectable mite to the general contribution. The new instruments invented by Dr. Lloyd and M. Weber, are now used upon the survey.

The portable declinometer of M. Weber, (perfected by Lieut. Riddell, and manipulated according to his instructions,) measures inclination, and also, by a subsidiary apparatus, the horizontal force, according to the method of Gauss. The bar being vibrated gives *magnetic moment. of bar* × *hor. mag. intensity.* And the same bar used to deflect another suspended at different distances, gives a series representing *mag. mom. of deflecting bar*÷*hor. mag. intensity*, and hence the true horizontal force is derived. Excellent results have been obtained by Fox's dip circle, with the use of the deflecting magnet. The axis in jeweled holes has a projecting stem, which is rubbed with an ivory disk to ensure perfect freedom of suspension. To this happy plan of creating a slight motion of the axis, a Frenchman has applied the significant term of shuddering. By means of these instruments the *declination, inclination, and intensity*, (both horizontal and vertical,) are determined, and thus whilst the useful and necessary are sought, valuable additions are made to the general magnetic researches.

Local attraction, and the consequent imperfection of courses on board of a vessel, will receive the attention their importance demands. Experiments made last summer on board of the brig Washington, belonging to the coast survey, showed a considerable local variation, and also suggested the means of its correction. This was the first occasion on which this subject had been investigated on the work. It is the design of the superintendent to apply the beautiful and simple mode of correction proposed by Mr. Airy. It is impossible to allude to his experiments on board the iron steamer Rainbow, in the basin of the Deptford dock-yard, and the calculations based upon them, without noticing this as a remarkable case where a theory purely scientific leads to the most useful practical results. Mr. Airy's combination of the theory of M. Poisson with regard to the equal attraction of solids and hollow spheres with his own hypothesis of the magnetic direction and intensity of the particles composing an iron steam-vessel, established the safe use of compasses where it was before supposed to be very insecure if not impracticable.

The subject of *tides* is now treated in a manner altogether new upon the survey. It seems to have been imagined, that the only purpose of tidal observations was to correct local soundings, and to ascertain the time of high water on the very days of full and change, or the vulgar establishment, and for this the solar interval alone was sought.

Even in this humble attempt, time appears to have been kept very loosely. Observers have been sometimes employed who had little idea of the importance of their office The reformation introduced is thorough. The times of high and low water, and the period of slack water, are found by watching the register unceasingly from half an hour before to half an hour after the change, and noting the time and height at very short intervals. It was first proposed to lay down these times and variations in height upon a large scale, and drawing, at the extremity of the curve traced through them with a free hand, a tangent parallel to the line of abscissas, to take the ordinate perpendicular to this tangent as the nearest approximation to the time of high water. But upon trial, this was not found to differ perceptibly from the numerical means of the times. The latter is therefore used as by far the most convenient. In the reductions, Dr. Bache has adopted the methods rendered familiar by the papers of Prof. Whewell and Mr. Lubbock. *Corrected establishments* are derived from the mean of the lunitidal intervals. As soon as observations accumulate sufficiently, at any prominent point, the curves of semimenstrual and diurnal inequality will be projected, the observations will be calculated for the effect of winds, and barometric pressure, and the variations in the times and heights of high water due to changes in the moon's parallax, declination, and motion in right ascension, will be investigated by a comparison between computation and observation.

The practical benefits of this system in determining the tide-factors, and in tracing the times, courses, and conflicts of the tides in the harbors and inland seas of the United States, cannot be too strongly enforced. And perhaps even the further suggestion may be humbly ventured, notwithstanding the unpromising results of Prof. Whewell's endeavors, that predictions to be relied on, which would be infinitely serviceable in the preservation of life and property in some of our bays and rivers, can be based upon future accumulated observations. If this hope should ultimately prove fruitless, no one will deny that so noble an object is worthy an effort.

Dr. Bache has also begun to set up *self-registering tide-gauges*—one has been in operation during the last six months, at Governor's Island, another is now in process of construction at the office in Washington. The former of these was invented, in its details, by Mr. Wightman, philosophical instrument-maker in Boston. The axis of a hollow copper cylinder, upon which the paper is secured, is connected with the pinion of a clock, and revolves correspondingly to the hands. The rim of a cylinder is divided in parts of an hour, and these divisions are transferred to the paper by a rule ingeniously contrived. A brass chain, (guided by the requisite pullies,) with the float in a well at one end, and a weight at the other, passes round a wheel in the prolonged axis of which, directly over the cylinder, is fixed the pencil. The well is guarded from the external motion of the water, and the motion of the float is communicated to the pencil by means of a screw.

The second tide-gauge is the invention of Mr. Saxton, late the balance maker of the U. S. Mint, and there particularly distinguished for his improvement of the parallel ruling-machine, by which it was made perfectly useful, after being thrown aside in despair by the original inventor. Mr. Saxton is now the constructor at the office of weights and measures, at Washington. His tide-gauge has two cylinders. One is carried by the clock, and receives the paper after the tidal curve is traced. The other carries the blank paper, and is assisted in its revolutions by a weight, thus easing the labor of the clock. The pencil acts between the two, and the intervals of time are noted by a marker connected with a striking apparatus.

In the former tide-gauge, the curves are repeated on the same paper—in Mr. Saxton's a continuous curve is traced from day to day. Both machines have reversal scales which can be adapted to the variable rise and fall at different places.

The leading principle in these gauges is the same as in those of Lieut. Palmer, published in 1833, and of Mr. Blunt, in 1838.

The dependence of practice upon theory is well established. The contributions of science to meet the daily wants of life, constitute her highest claims to respect and encouragement. In addition, however, to the useful results to be obtained from the researches into the nature of tides upon the shores of the United States, the friends of science, in this country, will be gratified to see that the superintendent has taken the first step towards rescuing the nation from the reproach of having hitherto entirely neglected this important branch of practical astronomy.

In conclusion it may be mentioned, that with twelve connected establishments determined at the office last winter, an attempt was made to deduce the place and direction of the co-tidal line, of XII hours upon this coast. The formula used by the superintendent was regarded as a means of approximation only, the co-efficients being subject to future modification.

The direction and velocity of *tidal currents* are now subjected to a rigorous investigation. They are determined for the normal condition of the tides, and for the effect of occasional deranging causes, such as winds, &c. The work is laid down upon circular and rectangular diagrams, both of them showing the courses and rates of motion. When accidental influences are the subject of examination, the mean is taken of several days' observations made under suitable circumstances, the temperature of the water being always recorded in the note-book. For this duty a new hydrographical party is added to the survey.

Connected with the study of currents is the *exploration of the Gulf Stream*, a work of vast labor and much time, for which the preparation is already begun. The magnitude of this task cannot be estimated. Its practical and philosophical bearings were ably treated by the committee of the scientific convention at

Washington, of which Lieut. Maury was chairman. They need not, therefore, be dwelt upon here; neither will any thing be said, at present, of the course of investigation to be pursued, farther than this, that deep-sea temperatures, and the shelving of the coast parallel to the land and water within the borders of the Gulf Stream, will not be overlooked.

As the operations of the coast survey depend upon the weather, the necessity for full and systematic *meteorological journals* is apparent.

Printed forms have been distributed by the superintendent, in which the weather, the state and temperature of the atmosphere, and the employments of the day are recorded by each assistant. At the new primary stations, the barometer and dew-point are noted. Besides the strict personal accountability, incidental benefits will spring from this mode of journalizing. Among them may be enumerated the means of estimating the probable progress of the work at the north and at the south, at different seasons of the year, the assistance they will afford in tracing the courses and studying the nature of storms, and the exceedingly valuable help they will supply for laying down, at some future time, a map of temperatures and climates throughout the coast region of the United States.

It would occupy too much space to mention the number of new printed forms now in use upon the work,—but their value cannot be questioned. Literal instructions may be differently construed by different persons, but the order to fill up a printed form according to the headings, leaves no room for misconstruction or latitude of interpretation. This, however, may be carried so far as to trammel individual effort, and control individual intelligence—but the evil is too apparent to have escaped notice.

The most serious and painful embarrassment is incurred by the present head of the survey, from the deficiency of good *instruments*. Just in proportion as the observer is proud and happy in the manipulation of good instruments, so is he dispirited and anxious with bad ones, which require endless repairs, tedious processes for the rectification of errors, and threaten, after all, to disgrace him by imperfect results. It seems worse than ridiculous to expect that a work of such delicacy and magnitude as the geodetic survey of the coast, can be conducted without an ample supply of the best instruments, yet Dr. Bache has been compelled to borrow a transit instrument from the State of Massachusetts, an altitude and azimuth circle from Columbia College, (now returned,) a repeating circle from West Point, and to purchase from Mr. Blunt, a Gambey theodolite, imported for his own use, which fully justified the high character of the maker. For this department there should be a separate appropriation, and it is to be hoped, that next winter the earnest appeals of the superintendent, supported by some intelligent members of Congress, who can appreciate the vital necessity of the case, will be heard with favor. In the mean time he is doing all in his power to remedy the gross deficiencies. A transit telescope has been ordered from Simms, and from Gambey a theodolite of the largest class, suited to astronomical observations and to the measurement of horizontal angles. Encouragement is given to our mechanics at home, from whom the smaller instruments are ordered, as they are wanted. A theodolite, by Patten, has lately been divided at the office with the dividing engine belonging to the coast survey. A vast deal of work, such as repairs, new mountings, &c., is done upon instruments in the workshops of the office at Washington. The vertical circle of the three feet theodolite has been separately mounted during the past winter, and a new horizontal circle graduated for the purpose. The fitting of the microscopes for the large theodolite has also been altered, so as to render the adjustments more easy and permanent. To these repairs may be added the making of drawing instruments, and engravers' tools. This work, done under the eye of those who are to use the instruments, is attended with a saving of time and expense.

The dividing engine of Mr. Troughton, belonging to the coast survey, which has been referred to, has been made automatic by the mechanical genius of Mr. Saxton. This instrument had been but little used. Two days were required to divide a circle, and the change of circumstances in the interval, the inconvenient position of the workman, and the effect of the heat of his body, created doubts of its accuracy after trials by experienced workmen. Now that it is self-acting, it performs, in one hour and ten minutes, the work which before consumed two days. The turning of a crank gives the necessary slow motion to the circle, raises the cutter, pushes it forward, and draws it back in such a manner, that it marks lines of four different lengths—10′, 30′, 1°, and 10°, and finally it throws itself out of gear when the division of the whole circle is completed. The centering was found defective, but now this and all other errors are effectually removed, except some small irregularities in the teeth of the main wheel, which will, in turn, be corrected. This engine admits a circle four feet in diameter, and will answer for the whole country.

There is one respect in which the superintendent has adopted a course entirely new, which must meet with the hearty approbation of the friends of learning throughout the country. In various parts of the United States, but principally attached to learned institutions, are found gentlemen who are led by taste, as well as professional pursuits, to make observations of value to the coast survey, especially in latitudes and longitudes. The superintendent purchases their results, of the highest value, because made by experienced observers, and with better instruments than the coast survey could furnish. Professors may profitably employ their summer vacations in similar labors. It will be recollected that Dr. Bache himself, while filling a chair in the University of Pennsylvania, made the magnetic survey of his native state during the term intervals of two years. Prof. Renwick, of Columbia College, was engaged last year in making experiments in Long Island Sound, with the new magnetic instruments before spoken of, for the coast survey. Mr. Bond, of Cambridge, communicates the meridian differences, by chronometers, between Boston and the British observatories. These have become numerous since the establishment of the line of steamers, and the commencement of Commodore Owen's survey of the Bay of Fundy. And Mr. Walker, of Philadelphia, has in charge the reduction of all the observations on record at the office, bearing upon the longitudes of coast-survey positions. Every one will admit that this duty, as extensive as it is laborious, could not be placed in more responsible keeping.

In the same spirit, observations at fixed observatories, occultations, eclipses, and moon culminations, and also for latitude, are procured and reduced to central points of the survey. It has already been mentioned, that the results of the transits over the prime vertical at Cambridge, have been communicated by Prof. Peirce. This system is the more necessary, because the coast survey can neither supply instruments nor observers for important occasions. The solar eclipse and transit of Mercury of last May, for instance, were observed by Dr. Bache, at Great Meadow station, near Taunton, and by two assistants, one at Portland, and one at a station near Baltimore ; and further than this the means of the work did not extend. But the records of the same phenomena are to be communicated from Cambridge, Brown University, and Philadelphia. Major Graham also has kindly placed his observations, made at Governor's Island, at the disposal of the superintendent. Collaterally with the same work in the office, scientific men, in private life, are engaged to report all the important calculations of the survey. The security against error afforded by employing persons, to compute, who have had no connection with the duties of the field or the observatory, is well understood.

The policy of the system now described, which gives support and encouragement to scientific men at home, which procures for the coast survey the use of good private instruments, and the assistance of accomplished observers and computors, which enlarges the sphere of labor in a way not less notable for its economy, than its practical benefits, cannot but receive universal sanction. It is intended to multiply, hereafter, observations at the principal stations of the work, of occultations and moon-culminating stars. The predictions of the former will be put in the hands of a distinguished mathematical professor.

Much remains to be completed in the area occupied before Mr. Hassler's death. To bring up this old work is an unthankful office ; but this is to be done whilst the constant progress of the new is not interrupted. An assistant of Dr. Bache's party is now employed in the Chesapeake. One of the two principal assistants is reconstructing the old triangulation in Delaware Bay. The important changes at Sandy Hook, developed by the renewed survey of last year, demand further examination. The number of similar cases may be expected to increase every year, especially as the survey advances to the southward. These facts are equally interesting to the geologist as to the navigator. There are few cases of change recorded in Mr. Lyell's treatise more striking than that at Sandy Hook. The investigation into their causes, belongs to the geologist, yet he must receive the basis of facts from the surveyor, and it will not be forgotten, that among these facts, are to be noted the local appearances, the direction in which the sea strikes the coast, the comparisons of soil as far as they may indicate the local connections, together with such others as will serve to guide the philosophical inquirer. It would lead to but a partial estimate of the value of the coast survey to omit these, as well as other considerations, upon which there is not time to dwell.

How well the coast survey has fulfilled the principal object of its institution, that is, the improvement of the navigation of our own shores, has been already amply illustrated. The channel newly determined at the entrance of New York bay, if known, would have permitted the entrance of D'Estaing's fleet, and it appears, from a comparison of the curves of soundings, that it must have existed at that time.

In Delaware Bay, there has been determined a new and straight ship channel, three smaller channels over the ridges of Cape May, and a dangerous shoal lying very near the main ship-channel. At the entrance of Delaware Bay, near Capes May and Henlopen, three shoals have been accurately defined; and a rock has been found at the entrance of New Bedford harbor, between the light-houses. But while navigation and its wants are the prominent object, information is incidentally furnished to facilitate works of fortification and internal improvement. Such was the case with regard to the fortifications projected near Sandy Hook, in the construction of the New York and New Haven railroad, and of the light-house on Tucker's Island, and in the improvements on League Island in the Delaware, and the project for carrying the Croton water to Brooklyn across East River.

Another point of real importance, which will receive the care and cordial co-operation of the superintendent, is the permanent position and systematic classification of buoys. This cannot be so well done until after the chart of the particular place is issued from the office. At present the buoys in our harbors are not well arranged, and hardly occupy the same place in two successive years. Taking the harbor of New York for an example; there are a certain number of black and white buoys precisely alike. If the mariner falls in with one of these buoys in a fog he has no means of knowing whether it marks the 'outer-middle,' or the 'west-bank,'—whether it is the buoy of the North channel, or of the S. W. Spit. That is, he must know his position by the bearings of familiar objects on the land, before the buoy can be a guide to him. The reader will at once perceive that if the British rule were adopted, of putting the buoys of one color on one side of the channel, and those of another on the other side, and numbering them in order from out, inwards, then the mariner in the night, or a fog, falling in with one of them, would know the precise spot he was in, and the course to be steered to the next buoy. Further details could be added concerning their moorings, as for example, the propriety of using the screw pile, introduced into this country by Capt. Wm. H. Smith of the Topographical Engineers, but the preceding hasty remarks show the importance of the subject, and its present state of neglect.

Since the coast survey has been under its present head, five sheets of charts have been issued; four of them are sheets of the large chart of New York bay, and were two-thirds done under Mr. Hassler. Two more are wanting to complete this set. They will contain the south side of Long Island, and the east entrance of the Sound, and may appear before this paper is published. The small chart of New York bay and harbor has been for sale for some time in the principal cities, and begins already to be in demand. The charts of Delaware Bay, of the coast of New York, and of Long Island Sound, are in the engraver's hands and advancing rapidly. In order to expedite the publication, and employ the skill and talent of other engravers, maps of the smaller harbors will be executed out of the office. The maps of Fisher's Island of the old work, of New Bedford and Annapolis, with the Severn of last year's work, are in progress. This is a part of the system of getting out results as soon as possible. The last mentioned will be engraved in a less elegant style of finish, being subject to future improvement, especially in their astronomical determinations.

But this subject, however interesting, must be brought to a close. It was said at the beginning of this article, that the chief aim of it was to convey some idea of the methods and principles of observation and reduction introduced into the work by Dr. Bache himself, and to show that this noble undertaking has lost no ground during the past eighteen months of its existence. Even more than this could be justly maintained, were it not above all things, desirable to avoid unseasonable and unprofitable comparisons.

As the duties of the survey are numerous, various, and comprehensive, so the labor of arranging them, of adjusting each to the other, and making all harmonize together, of regulating their details and embracing their extent, of giving instructions to the head of every party whether in the field, or the observatory, or on the water, and receiving in return his reports and communications, is onerous and engrossing in the extreme. This is attended to by the present superintendent personally, while all the angles measured, astronomical, magnetic, and other observations taken, and calculations made at the stations of the first order, are executed by himself, or under his immediate control.

There is one point of the highest import to the prosperity of the work, which must not be passed over. The coast survey, heretofore endangered by the absence of a controlling public opinion, now enjoys its efficient support, both in Congress and in the country generally. It enjoys, moreover, internal peace and harmony, a condition essential to the prosecution of scientific labors, and honorable to all.

It only remains to add, that the matters here treated being considered familiar to the general readers of this Journal, it has not been thought necessary to consume space by strict references to the authorities cited.

Art. II.—*A Letter to Berzelius on Chemical Nomenclature;* by Robert Hare, M. D., Professor of Chemistry in the University of Pennsylvania.

Philadelphia, May, 1845.

Esteemed Sir,—I am extremely grateful to you for the good will which has induced you to occupy so much of your valuable time and attention in answering my letters, and regret that I have not succeeded in so expressing myself, whether in French or English, as to make you comprehend my opinions. I shall begin to think that in theoretic elucidation, as well as in physical illumination, it may be more difficult to make luminous impressions on bodies, in proportion as they are themselves preeminently the sources of light.

In your letter of the 25th of February, 1844, you describe my opinion of a salt in the following words: "Vous fondez l'idee d'un sel uniquement sur la composition sans egard aux proprietes, vous ne considerez, comme un sel que ce qui est composé d'un combinaison binaire appelleé *base* et un autre combinaison binaire appelleé *acide.* Les sels dit haloide, ne sont pas, d'apres vous, des sels, puis qu'ils ne sont compose que de deux elements et ne contienent ni base ni acide." That this account of my opinion is erroneous must appear from the following language, held in my letter to Prof. Silliman, which first gave rise to our correspondence on the subject of nomenclature.

"The most striking feature in the nomenclature of Berzelius, is the formation of two classes of bodies, one called '*halogene*,' or salt producing, because they are conceived to produce salts directly; the other '*amphigene*,' or both producing, being productive both of acids and bases, and of course indirectly of salts. To render this division eligible, it appears to me that the terms acid, base, and salt, should, in the first place, be strictly defined. Unfortunately, there are no terms in use, more broad, vague, and unsettled in their meaning. Agreeably to the common acceptation, chloride of sodium is pre-eminently entitled to be called as a salt; since in common parlance, when no distinguishing term is annexed, salt is the name of that chloride. This is quite reasonable, as it is well known that it was from this compound, that the genus received its name. Other substances, having in their obvious qualities some analogy with chloride of sodium, were, at an early period, readily admitted to be species of the same genus; as for instance, Glauber's salt, Epsom salt, sal-ammoniac. Yet founding their pretensions upon similitude in obvious qualities, few of the substances called salts, in the broader sense of the name, could be admitted into the class. Insoluble chlorides have evidently, on the score of properties, as little claim to be considered salts, as insoluble oxides. Luna cornea, plumbum corneum, butter of antimony, and the fuming liquor of Libavius, are the appellations given respectively to chlorides of silver, lead, antimony, and tin, which are quite as deficient of the saline character as the corresponding compounds of the same metal with oxygen. Fluoride of calcium (fluor spar) is as unlike a salt as lime, the oxide of the same metal."

"On the other hand, if instead of qualities, we resort to composition as the criterion of a salt; if, as in some of the most respectable chemical treatises, we assume that the word salt is to be employed only to designate compounds consisting of a base united with an acid, we exclude from the class chloride of sodium, and all other 'haloid salts,' and thus overset the basis of distinction between 'halogene' and 'amphigene' elements. Moreover, while thus excluding from the class of salts, substances which the mass of mankind will still consider as belonging to it, we assemble under one name, combinations opposite in their properties, and destitute of the qualities usually deemed indispensable to the class. Thus, under the definition that every compound of an acid and a base, is a salt, we must attach this name to marble, gypsum, feldspar, glass and porcelain, in common with Glauber's salt, Epsom salt, vitriolated tartar, pearlash, &c. But admitting that these objections are not sufficient to demonstrate the absurdity of defining a salt as a compound of an acid and a base, of what use could such a definition be, when, as I have premised, it is quite uncertain what is an acid or what is a base. To the word acid different meanings have been attached at different periods. The original characteristic sourness, is no longer deemed essential. Nor is the effect upon vegetable colors, treated as an indispensable characteristic; and, as respects obvious properties, can there be a greater discordancy, than that which exists between sulphuric acid and rock crystal; between vinegar and tannin; or between the volatile odoriferous liquid poison, which we call prussic acid, and the inodorous concrete material for candles, called margaric acid?

"While an acid is defined to be a compound capable of forming a salt with a base, a base is defined to be a compound that will form a salt with an acid. Yet a salt is to be recognized as such, by being a compound of the acid and the base, of which, as I have stated, it is made an essential mean of recognition."

On reperusing the passages which I have thus annexed, you will perceive, that I have treated as absurd the idea of restricting our conception of a salt to a compound formed of an amphide acid and an amphide base, and that I have denounced that of depriving the chloride of sodium of its appropriate name, and eliminating from the class of salts compounds analogous to this chloride in composition and properties.

In the following paragraphs, taken from my "*Effort to refute the arguments advanced in favor of the existence, in amphide salts, of a compound radical like cyanogen*," I have objected to the employment of the word salt as a corner-stone of any scientific superstructure. "27. *It much surprises me, that* *when so much stress is laid upon the idea of a salt, the impossibility of defining the meaning of the word escapes attention. How is a salt to be distinguished from any other binary compound? When the discordant group of substances which have been enumerated under this name, is contemplated, is it not evident that no definition of them can be founded on community of properties? and, by the advocates of the new doctrine, composition has been made the object of definition, instead of being the basis. Thus, agreeably to them, a compound is not a salt, because it is made of certain elements; but, on the contrary, an element, whether simple or compound, belongs to the class of salt radicals, because it produces a salt. Since sulphur, with four atoms of oxygen,* SO^4, *produces a salt with a metal, it must be deemed a salt radical.*"

"30. *Evidently the word salt has been so used, or rather so abused, that it is impossible to define it, either by a resort to properties or composition; and I conceive, therefore, that to make it a ground of abandoning terms which are susceptible of definition, and which have long been tacitly used by chemists in general, in obedience to such definition, would be a retrograde movement in science.*"

On perusing the preceding passages, you must perceive that the difference between us, is not, that while you would build upon one idea of a salt, I would build upon another; it lies, on my part, in the rejection, as a basis of nomenclature or classification, of a word, so vaguely used, and so undefinable as that in question.

As respects another misapprehension, it never occurred to me, that binary haloid compounds, were less entitled to be considered as salts, on account of their having no more than two elements. The tendency of my opinions has been to consider the chloride of sodium, as the basis of the saline genus, and to object to the treatment of any body as a salt, which has not some analogy with it in properties, if not in composition.

The feature in your nomenclature and classification which is most discordant with that which I have proposed, is the distinction which you have attempted to make between the binary compounds formed by halogen bodies with electro-positive radicals, and those formed with the same radicals by amphigen bodies. I cannot conceive upon what ground the former, for the most part, are more worthy of being considered as salts than the latter; nor whereupon the amphide compounds resulting in the one case, are to be considered as acids or bases, according to their relation to the voltaic poles, more than are the haloid compounds resulting in the other.

Your nomenclature and your classification, are founded on the words *acid*, *salt*, and *base*, and yet you have not given any consistent definition of the ideas to be attached to either. These words have been shown to be employed by you in different senses, whether as respects composition or properties.

On this subject you will find the following comments in my letter to Prof. Silliman above quoted.

"*An attempt to reconcile the definitions of acidity given by Prof. Berzelius, with the sense in which he uses the word acid, will, in my apprehension, increase the perplexity.* It is alleged in his Traite, page 1, Vol. II, '*that the name of acid is given to silica and other feeble acids, because they are susceptible of combining with the oxides of electro-positive metals, that is to say with salifiable bases, and thus to produce salts, which is precisely the principal character of acids.*' Again, Vol. I, page 308, speaking of the *halogene* elements, he declares that 'their combinations with hydrogen, are not only acids, but belong to a series the most puissant that we can employ in chemistry; and in this respect they rank as equals with the strongest of the acids, into which oxygen enters as a constituent principle.' And again, Vol. II, page 162, when treating of hydracids formed with the halogene class, he alleges, '*The former are very powerful acids, truly acids, and perfectly like the oxacids; but they do not combine with salifiable bases; on the contrary, they decompose them and produce haloid salts.*'

"In this paragraph, the acids in question are represented as pre-eminently endowed with the attributes of acidity, while at the same time they are alleged to be destitute of *his* '*principal character of acids*,' the property of combining with salifiable bases.

"In page 41 of the same volume, treating of the acid consisting of two volumes of oxygen and one of nitrogen, considered by chemists generally as a distinct acid, Berzelius uses the following language. 'If I have not coincided in their view, it is because, judging by what we know at present, the acid in question cannot combine with any base, either directly or indirectly, that consequently it does not give salts, and that salifiable bases decompose it always into nitrous acid and nitric oxide gas. It is not then a distinct acid, and as such ought not to be admitted into the nomenclature.' "

I suggested a definition here subjoined, which is founded upon your own electro-chemical classification, and which is no more than an enunciation of a rule acted upon, and consequently sanctioned tacitly by yourself and all other chemists. The definition in its amended form, as given in my text-book, is as follows:—

"*When of two substances capable of combining together to form a tertium quid, and having an ingredient common to both, one prefers the positive, the other the negative pole of the voltaic series, we must deem the former an acid, the latter a base; also, any body capable of saturating an acid, as above defined, is a base, and any body capable of saturating a base, as above defined, is an acid.*"

It follows that agreeably to the nomenclature proposed by Faraday, every acid is an "anion," every base a "cathion."

But to proceed to another part of the letter, which I have had the honor to receive from you, it is there alleged that although "*nitrate calcique*" (nitrate of lime) is a deliquescent salt, while fluor spar is a stone, you class them together because they have, in common, the property of yielding with sulphuric acid *gypsum* and a *free acid.* But allow me respectfully to inquire how, consistently with your system, sulphuric acid can extricate a free acid from fluoride of calcium? By your own premises fluoride of calcium is a salt, then wherefore is not the fluoride of hydrogen a salt? If it be a salt, where is the analogy between the reaction of the sulphuric acid with the nitrate of lime and the fluor? In the former case sulphuric acid liberates an acid by a superior affinity for a base already existing; in the latter case, by causing the oxygen of its combined water to unite with calcium, it *generates* a base and afterwards combines with it; and, while decomposing one fluoride, gives rise to another. In the instance of the nitrate, one amphide salt is replaced by another amphide salt, while an acid is liberated; in the instance of the fluoride, an haloid salt is replaced, both by an ampbide salt and another haloid compound. As, according to your system, this compound consists of a *halogen*, or salt-generating body, combined with a radical, it should be treated as a simple salt.

If, as stated in your Traité, an ability to combine with bases be an essential attribute of acidity, how can the fluoride of hydrogen be an acid, unless my view of the question be admitted, agreeably to which the electro-negative fluorides are fluacids, the electro-positive fluorides, fluobases, while the compound of a fluacid and fluobase is a salt, at least as much as feldspar, or marble. With what other base than a fluobase, can the fluoride of hydrogen unite as an acid, so as to fulfil the conditions of your definition ?*

I am prevented from supposing that by adopting the salt radical theory, you would rest the analogy of the cases cited, on the existence of a compound radical oxynitrion, in the nitrates, because in your letter of the 15th of September, you allege, that you prefer to consider oxysalts as consisting of two oxides. Besides, I hope you will consider the arguments which I have advanced against that theory, as unanswerable.

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* On this subject the following remarks were made in my letter on your nomenclature above referred to. "In common with eminent chemists Prof. Berzelius has distinguished acids in which oxygen is the electro-negative principle as *oxacids*, and those in which hydrogen is a prominent ingredient as *hydracids*. If we look for the word radical, in the table of contents in his invaluable treatise, we are referred to page 218, volume first, where we find the following definition, '*the combustible body contained in an acid, or in a salifiable base, is called the radical of the acid or of the base.*' In the second volume, page 163, hydracids are defined to be 'those acids, which contain an electro-negative body, combined with hydrogen ;' and in the next page it is stated, that 'hydracids are divided into those which have a simple radical, and those which have a compound radical. The second only comprises those formed with cyanogen and sulphocyanogen.' Again, in the next paragraph, 'no radical is known that gives more than one acid with hydrogen, although sulphur and iodine are capable of combining with it in many proportions. If at any future day more numerous degrees of acidification with hydrogen, should be discovered, their denomination might be founded on the same principles as those of oxacids.' Consistently with these quotations, all the electro-negative elements forming acids with hydrogen, are radicals, and of course by the definition of Prof. Berzelius, combustibles; while hydrogen is made to rank with oxygen as an acidifying principle, and is consequently neither a radical nor a combustible. Yet page 189, volume second, in explaining the reaction of fluoboric acid with water, in which case fluorine unites with hydrogen and boron, it is mentioned as one instance among others in which fluorine combines with two combustibles.

"I am of opinion that the employment of the word hydracid, as co-ordinate with oxacid, must tend to convey that erroneous idea, with which, in opposition to his own definition, the author seems to have been imbued, that hydrogen in the one case plays the same part as oxygen in the other. But in reality the former is eminently a combustible, and of course is the radical by his own definition."

But admitting the existence of oxynitrion in the nitrates, wherefore should not fluorine in fluacids, play the same part as oxygen in oxacids. If a compound radical be formed when two oxides come together, wherefore should there not be a compound radical formed by the meeting of two fluorides? If in the one case, all the oxygen goes to form a compound radical, in the other ought not all the fluorine to perform an analogous part? Hence if on the one hand we admit the existence of *oxynitrion*, on the other we must admit that of *fluohydrogenion.*

It will be conceded that there is a great analogy between the acid haloid compounds of hydrogen erroneously named hydracids, and those formed by the same radical with sulphur, selenium, and tellurium. I have designated the three last, and likewise water when acting as an acid, as amphydric acids, while I have designated the haloid hydracids so called, as halohydric acids; founding these appellations on your words amphigen and halogene. Can it be imagined that although when either of the amphydric acids, sulphydric acid for instance, is presented to a corresponding amphide compound, sulphide of potassium for instance, that a compound radical is generated, so that the formula of the resulting sulpho-salt is to be HS^2P, and yet that when fluohydric acid is presented to the fluoride of potassium, there being no generation of a radical, the formula of the resulting compound is to be $FH+FP-$.

You consider it as an objection that I must class the oxide of sodium with the chloride and sulphide of the same metal, notwithstanding the diversity of their properties; but how can this be a consistent objection, when, according to your nomenclature, the chloride of sodium is classed not only with the fuming liquor of Libavius, the butyraceous and volatile chlorides, which though analogous in composition differ from it in properties extremely, but also with feldspar, gypsum, glass, and marble, which are utterly different from it in composition, as well as in properties?

If in the case of the nitrate of lime and fluor spar we are to overlook that the latter is a stone, the former a deliquescent salt, in consideration of the alleged community of results obtained by reaction with sulphuric acid, let us subject the sulphide and chloride of sodium to the same test. Do we not obtain from either, sulphate of soda and a free acid? Is there not a much greater analogy between chlorohydric acid and sulphydric acid, than between the nitric acid and the fluoride of hydrogen? Under this aspect can it be reasonable to class together the nitrate of lime and fluor spar as simple salts, and yet exclude the sulphides from the same class? Are not the sulphides more analogous to the chlorides and fluorides than the nitrates, in the very trait to which you have referred? I allude to the evolution from either by reaction with sulphuric acid of a like base and of one of the acids improperly called hydracids.

It is considered as objectionable that chloride of sodium, a neutral salt "par excellence," should be deemed a base. But I would ask, whence originated the nominal *neutrality* of this chloride; did it not spring from the old abandoned notion of its consisting of muriatic acid and oxide of sodium? That it is a salt *par excellence*, I admit, but deny that it is a *neutral* salt agreeably to the idea associated with the term neutral as applied to the sulphates of potash and the sulphate of soda, in contradistinction to the acid bisulphates of these bases. That it is neutral or inert, as respects its reagency with vegetable colors, ought not, as I conceive, any more to be an objection to its claims to the basic character, than the like inertness is an objection to the basic pretensions of the oxides of the metals proper, among which very few, if any, have any alkaline reaction. This is more properly a test of *alkalinity* than of basidity.

Since water, alumina, and some other oxides, are considered as capable severally of acting as an acid in some compounds and as a base in others, wherefore may not the same substance have the attributes of a salt in one case, and yet in others act as a base? Which is the most remote from the character of a base, is it the salt or the acid?

I am obliged to you for the information given at the close of your letter. I do not know whether you have ever met with the account given in the Bulletin of the proceedings of the American Philosophical Society, of my success in fusing pure rhodium and iridium, by the hydro-oxygen blowpipe.

I have been for some time endeavoring to perfect some new methods of analyzing organic substances by burning them in oxygen gas.

With the highest esteem, I am yours sincerely,

ROBERT HARE.

ART. III.—*Description of a Singular Case of the Dispersion of Blocks of Stone connected with Drift, in Berkshire County, Massachusetts;* by EDWARD HITCHCOCK, LL. D., President of Amherst College.

[Read before the Association of American Geologists and Naturalists, at Washington, May, 1844.]

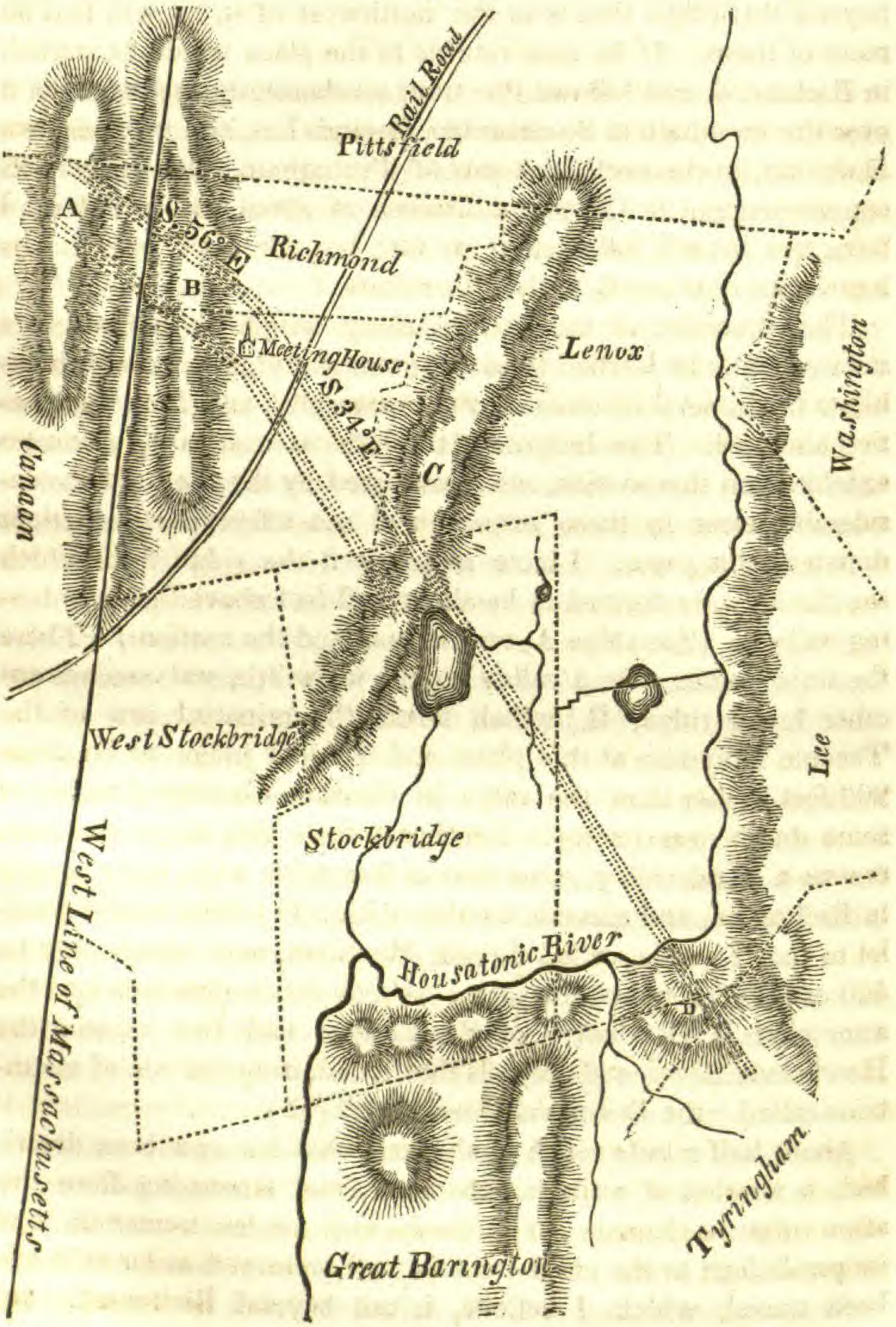
THE precipitous ridges and deep vallies of western Massachusetts may be regarded as classic ground on the subject of drift. The force by which the bowlders were dispersed and the rocks smoothed and striated, swept over those ridges in an oblique direction; and we are there presented with much striking evidence how independent was this force of existing agencies and of the present configuration of the surface. The leading facts respecting the drift of that region, I have presented in my Final Report on the Geology of Massachusetts. But within the past year I have been invited by Dr. S. Reid, of Richmond in Berkshire County, —himself a zealous naturalist,—to examine a very curious case of transported blocks, found in that town and the adjoining ones; and it is so different from any case which I have met with, that I am anxious to bring it to the notice of geologists. For anomalous cases in natural history sometimes reveal to us a general law that governs a large class of phenomena, or rather they lead us to a wider induction than we had made from the ordinary facts.

I wish first to mention, that Dr. Reid has given some account of this case in the Berkshire Farmer, a newspaper published in Lenox. But as he did not go into those details which give the case an important aspect in relation to prevailing theories of drift, I shall attempt to supply that deficiency.

As one passes a few rods west of Dr. Reid's residence, and about half a mile northeast of Richmond meeting-house, he will see, on either side of the road, numerous angular blocks of stone, of a character quite different from the rock in place, which is limestone. In general the fields are quite free from loose blocks. But on looking southeasterly at this spot, he will see a well marked train of blocks, perhaps thirty or forty rods wide. He may be surprised to see how distinct are the limits of this train. But if he do not follow it further, he will not probably regard it as a peculiarity of much importance; if, however, he turns northwesterly, and follows the train on foot through woods and cleared fields, he will find it pursuing a very direct course, over hill and valley, for about three miles, when he will ascend a ridge, perhaps 600 feet high, in the town of Canaan, New York, where the rock in place corresponds to the blocks of the train; and beyond this ridge, that is to the northwest of it, he will find no more of them. If he now returns to the place where he started, in Richmond, and follows the train southeasterly, he can trace it over the mountain in Stockbridge, through Lee, and up Beartown Mountain, in the northwest part of Tyringham; that is, from its commencement in Canaan, a distance of about fifteen miles. I have not myself followed it so far; but Dr. Reid has, and he knows not how much farther it extends.

The character of the surface along which these blocks are strewed, may be learned from the accompanying map, which exhibits the general features of the topography, and from the section annexed. The heights of the hills, as well as the distances exhibited on this section, were estimated by the eye. But a considerable error in these respects will not affect the deductions drawn in this paper. I have represented the ridge from which the blocks were derived to be about 600 feet above the neighboring vallies. (See ridge A, on the map and the section.) There the train passes over a valley a mile in width, and ascends another broad ridge, (B,) which forms the principal part of the Taconic Mountain at this place, and which I judge to be about 200 feet higher than the ridge in Canaan,—having a valley of some depth near its top. Southeast from this ridge the train crosses a broad valley, some four or five miles wide, lying mostly in Richmond, and ascends another ridge, (C,) lying nearly parallel to the Taconic, called Lenox Mountain, and which may be 500 or 600 feet above the plain. From this it descends into the somewhat level country of Stockbridge and Lee, crosses the Housatonic River, and ascends that broad, irregular pile of mountains called "the Beartown Mountains," (D.)

About half a mile south of the train that has now been described, is another of a similar character, and emanating from the same ridge in Canaan. The blocks in it are less numerous, but its parallelism to the other train is well preserved as far as it has been traced, which, I believe, is not beyond Richmond. Its width is about the same as the other. Between the trains, and in other parts of the town, we meet occasionally with a block of the same kind as the trains: but they are rare; though Dr. Reid thinks it possible that a third train may be found in the south part of the town, where he has observed the blocks to be more numerous.



The rock forming these blocks, I incline to refer to the talcose slate of the Taconic Mountain; and yet it is quite distinct from the usual talcose slate of that range, which forms the west part of Richmond. It is a very hard and tough rock, of a greenish color, and often considerably granular, resembling the older varieties of graywacke. It frequently contains veins of what appears to be picrosmine, which is quite characteristic, and readily identifies it with the rock in Canaan. In some spots on the parent range, we can see the places where the ragged fragments were torn off by some giant force, and the fracture has yet a considerable degree of freshness,—for this is one of the most enduring of all rocks, being highly magnesian. This ridge, it ought to be remarked, is a part of the Taconic range, which here is separated into several rather low ridges. On the west of the ridge in Canaan, succeed limestone, clay-slate, and the oldest of the Silurian or graywacke rocks.

As we go east from the parent range, the west ridge, as we enter Massachusetts, is the common talcose slate of the Taconic. Then succeeds, in the valley of Richmond, a crystalline limestone; then mica slate in Lenox Mountain; then limestone to the Housatonic; and finally, in Beartown Mountain, quartz rock and gneiss. These rocks are not marked on the map, because they are of no great importance to the point in hand.

Section along the route of the train of blocks.

I ought to add that the rock of which these blocks consist, is of that intermediate kind which will be referred to different places in the geological scale by different geologists, according to their theoretical views. Nevertheless, it has a character so distinct that even a common observer would not mistake it or confound it with any of the rocks in place over which the blocks are strewed. The opinion that it is serpentine I consider quite untenable.

The blocks composing the trains seem to be confined to the surface. We have a fine opportunity of seeing this where the main train crosses the western railroad. At that spot the road is excavated to a considerable depth into drift, that is rounded. But not one of these blocks is seen mixed with it. They lie only on the surface. Nor could I see any evidence on any of them, that they had been at all subject to attrition. Yet the hills over which they have passed are all smoothed and furrowed on their western sides, and by a force acting in the same direction as that which conveyed these angular blocks; but they could not have been concerned in the attrition, otherwise their angles would have been worn off. In short, it is certain that these blocks must have been transported in some very quiet manner to their present situation. Indeed, had they been blasted by human power, and conveyed by men to their places, and arranged carefully in lines, and then suffered to weather for a few centuries, they would appear much as they now do.

I have spoken of these trains as if they pursued an undeviating course. But I must now modify this statement. From their starting point to the middle of Richmond, I could discover no deviation from a right line. But when we come into the broad valley lying between Richmond and Lenox Mountain, the direction changes about 30°. As far as Richmond, the course by the true meridian is E. 34° S. From thence the remainder of the distance, certainly to Lenox Mountain, it is E. 56° S. Possibly there may be another change of a few degrees beyond Lenox Mountain. This change in the course may be seen on the map, where the trains are shown by dotted lines.

The quantity of these blocks, taking the whole length of the trains into account, is immense. In some places they almost cover the ground; as where we begin to ascend the hill to the northwest of Richmond meeting-house. In other places the interval between them is several rods.

Nor is the size of the individual blocks small. They are usually some feet in diameter, and now and then we meet with examples of extraordinary magnitude. At the foot of the hill, northwest of Richmond meeting-house, is the largest I saw. It is 140 feet in circumference, and 12 feet thick. A rod or two distant lies a fragment, which has been detached from the main block, which is 19 feet long, 20 feet broad, and 5½ feet thick. These two blocks, originally one, contain 16,000 cubic feet, and weigh about 1,370 tons. I have seen others as large nearly; but in several instances they were split into pieces, as if they had fallen from a considerable height into their present position.

Such are the facts. What inferences can we draw from them?

In the first place, these trains of blocks must have been scattered during the latter part of the drift period, and by the same general agency that accumulated the rounded detritus beneath the blocks, and smoothed and furrowed the rocks. The fact that the trains of blocks lie upon the surface above the common drift, proves that they were brought there by an agency more recent than that which accumulated the inferior detritus. But as the force acted in both instances in the same direction, that is, southeasterly, and must have been very different from any other agency that has since acted in that region, we have no good reason for calling in other powers to explain effects so nearly alike.

In the second place, it is impossible to explain this case by any theory of drift, which refers it to the agency of currents of water alone, or of the water and the detritus driven along by its power. The very oblique direction which the train takes across high ridges, would alone refute the idea that water could have done it, even though the whole northern ocean had rushed with the violence of a descending cataract over the spot. But still more absurd does such an hypothesis appear, when we learn that thousands of blocks are strewed over a distance of fifteen miles, not the eighth of a mile in width, and preserving an uniform direction. He who can suppose that a current of water would thus confine such a train of blocks,—some of them of enormous weight,—within such narrow and exact limits, and that too without wearing off the angles of the blocks, must have a very different idea of the dynamics of currents of water from what I have.

In the third place, it is almost equally difficult to explain the dispersion of these blocks by floating icebergs. If the number of blocks had been only one or two, or even not more than fifty, it might be possible that a large iceberg should have dropped them. But what iceberg could have loaded itself with enough of these blocks to have strewed them so thickly for so many miles? And who will believe that successive icebergs, striking against the same ridge in Canaan, should have torn off and borne away successive blocks in precisely the same direction, so as to have lengthened out the train? Besides, although an iceberg would have the power to break off the blocks, where is the agency by which they would be raised upon its back?

Finally, I know of but one or two facts in geology that can furnish us with the slightest clue to the manner in which these trains of blocks were produced. One is, the transportation of blocks of stone in what is called packed ice, upon rivers in high latitudes. These sometimes form lines of bowlders along the shore for a considerable distance; as in the river St. Lawrence, described by Mr. Lyell in Vol. I of his Principles of Geology, (p. 371.) If, therefore, we could suppose a large river passing from the mountain in Canaan across the hills southeasterly, and the climate much colder, it might afford a possible though very improbable explanation of the case. But one has only to look at the region to see, that in its present configuration, this is out of the question, unless a river can flow without a bed, and over ridges 600 or 800 feet high. And as to any essential change of configuration there since the drift period, I think I have proved it absurd in my Final Report.

The second case to which I referred is that of the medial moraines of glaciers; that is, trains of blocks borne along on the back of the middle of the glacier, in consequence of the union of two glaciers, whereby the lateral moraines of the separate glaciers are forced to the surface after the coalescence. One has only to look at such moraines, as represented by Agassiz in his Etudes sur les Glaciers, to see that they a good deal resemble the trains of blocks in Richmond; and then, such a mode of transport would show why they are not rounded. But when we come to examine the country with reference to a glacier, we shall find it about as difficult to imagine the existence of one there as of a river. The country, to the northwest of the ridge in Canaan, from whence the blocks started, descends as far as Hudson River, say 40 or 50 miles; and it is not till we have gone 100 or 200 miles beyond that river, that we have any mountains of much height. And then, if we can imagine a glacier to start from the ridge in Canaan, it must ascend 100 or 200 feet, according to my estimate, in order to go over the next ridge into Richmond; and then again ascend Lenox Mountain and Beartown Mountain. It is quite as difficult, also, to imagine any cause why the glacier should change its course after passing the first ridge. If it had gone directly down the north and south valley after going over the first ridge, it would not be strange; but it seems to have persisted in going over the next ridges.

A case, which approaches more nearly to the one I have described in Berkshire, is given by Mr. Darwin as occurring in the Falkland Islands, south latitude 52°. "The bottoms of the valleys," says he, "are covered in an extraordinary manner by myriads of great angular fragments of the quartz rock. The whole may be called a 'stream of stones.' The blocks vary in size from that of a man's chest to ten or twenty times as large; and occasionally they altogether exceed such measures. Their edges show no sign of being water-worn, but only a little blunted. The width of these beds varies from a few hundred feet to a mile."*

The slope of these streams of stones is about 10°, and they appear to have travelled from the heads of the vallies since the land was raised above the sea. But Mr. Darwin supposes them to have been hurled from the nearest slopes, and then, by powerful earthquakes, to have been leveled into continuous sheets. Did the blocks in Berkshire occupy the bottoms of the vallies, this explanation might perhaps apply to them. But the position of the trains in an oblique direction across the hills and the vallies, renders this theory inapplicable. In short, I find so many difficulties on any supposition which I can make, that I prefer to leave the case unexplained till more analogous facts shall have been observed.

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* Narrative of the Voyage of the Beagle, Vol. III, p. 253.

Art. IV.—*Meteorological Observations made at Hudson, Ohio, Lat.* 41° 14′ 42″ *N., Long. 5h. 25m. 40s. W., during the years* 1841, '2, '3, *and* '4, *with a summary for seven years;* by Elias Loomis, Professor of Mathematics and Natural Philosophy in the University of the city of New York.

In Volume xli, pp. 310—330 of this Journal, is given a summary of the Hudson observations for 1838, '39, and '40. It is now proposed to continue this summary, and append the average results for seven years. The position of the instruments has throughout remained unchanged, and the same hours of observation have been adhered to. During the past four years, not a single observation, except of the hygrometer, has been lost. They were all made by myself, with occasional exceptions, until October, 1843, from which time until July, 1844, they were made by Mr. S. T. Seelye, a graduate of Western Reserve College. Those for August and September were made by Mr. Lemuel Bissel, and those for the next five months by Prof. Nooney. The year is considered as commencing with March. The following observations of the barometer, are all corrected for capillarity, and reduced to 32° F.

BAROMETER.

Months	1841.		1842.		1843.		1844.		Mean of seven years.		Diurnal oscillation	Pressure of the vapor.		Gaseous atmosphere.	
	9 A. M.	3 P. M.	9 A. M.	3 P. M.	9 A. M.	3 P. M.	9 A. M.	3 P. M.	9 A. M.	3 P. M.		9 A. M.	3 P. M.	9 A. M.	3 P. M.
March,	28·783	28·751	28·848	28·797	28·768	28·728	28·806	28·773	28·793	28·751	·042	·192	·209	28·601	28·542
April,	·786	·737	·737	·687	·767	·729	·933	·882	·806	·761	·045	·288	·315	·518	·446
May,	·792	·754	·784	·755	·796	·751	·814	·755	·769	·725	·044	·372	·389	·397	·336
June,	·789	·748	·783	·742	·805	·773	·843	·804	·792	·755	·037	·541	·582	·251	·173
July,	·874	·828	·910	·879	·878	·837	·796	·777	·856	·822	·034	·636	·664	·220	·158
Aug.,	·926	·878	·919	·885	·909	·873	·779	·754	·876	·838	·038	·601	·638	·275	·200
Sept.,	·829	·783	·903	·858	·900	·847	·936	·895	·893	·846	·047	·491	·527	·402	·319
Oct.,	·886	·841	·866	·809	·763	·738	·875	·832	·858	·812	·046	·308	·324	·550	.488
Nov.,	·781	·744	·842	·800	.898	·870	·827	·775	·851	·806	·045	·197	·208	·654	·598
Dec.,	·790	·757	·864	·821	.879	·838	·767	·723	·812	·774	·038	·160	·166	·652	·608
Jan.,	·774	·737	·815	·784	·789	·762	·812	·774	·823	·785	·038	·146	·154	·677	·631
Feb.,	·780	·729	·741	·701	·876	·826	·796	·742	·817	·767	·050	·148	·161	.669	·606
Year,									28·829	28·787	·042	·340	·362	28·489	28·425

The mean diurnal oscillation is for spring ·0437; for summer ·0363; for autumn ·0460; and for winter ·0420. It is least in summer and greatest in autumn. Average for the year ·0420, differing but slightly from the results of the first three years.

The mean pressure at Hudson for the seven years is 28·808. The reduction to the level of the sea is given below, to which I have added for comparison three years' observations at Cambridge, and two years' observations at Toronto.

Hudson, ...	28·808
Reduction for 1141 feet, . .	+1·222
Correction for gravity, . .	−·010
Zero error, . . .	+.007
	30·027
Cambridge, . . .	29·940
Reduction for 50 feet, . .	+·055
Correction for gravity, . .	−·007
	29.988
Toronto, ...	29·608
Reduction for 342 feet, . .	+·378
Correction for gravity, . . .	−·004
Zero error, . . .	−·004
	29·978

Comparing these results with those given in my former article, we have—

Hudson, ...	30·027
Cambridge, . . .	29·988
Toronto, ...	29·978
New York, . . .	29·977
Montreal, ...	29·989
Quebec, ...	29·919

The excess of pressure at Hudson is remarkable, and indicates a probable error in the assumed elevation of the place. If we suppose the elevation to be 1092 feet, the resulting pressure will be 29·983. This gives an error of 50 feet in the assumed elevation of Hudson, which seems hardly admissible; nevertheless that result (1141 feet) was derived from an imperfect connexion with a hasty rail-road survey from lake Erie.

It has been justly remarked by Colonel Sabine, that the oscillations of the barometer are the complex effect of changes in the pressures of the vapor and of the gaseous atmosphere; and that while we confine our attention to this complex effect, we fail to detect the causes of the phenomena. But as soon as we separate the phenomena of the vapor and the air, we perceive the dependence of each upon temperature. Columns thirteen and fourteen in the preceding table, exhibit the pressure of the vapor as deduced from the observations of the hygrometer on page 271; and subtracting these numbers from the total pressure, we obtain the pressure of the gaseous atmosphere, shown in the last two columns of the table.

We perceive then that the pressure of the vapor is greatest in the hottest months, and at the hottest hour of the day. On the contrary, the pressure of the gaseous atmosphere diminishes in the summer months, and augments in the winter months; it also diminishes as the heat of the day increases.

The cause of this phenomenon is obvious. As the temperature of the day increases, the air in contact with the earth's surface becomes warmed; it rises, and a portion diffuses itself in the higher regions of the atmosphere, over spaces where the temperature at the earth's surface is less. Thus the weight of the column is diminished. As the temperature declines, the column contracts, and receives in turn a portion of air which passes over in the upper regions from spaces where a higher temperature prevails, and thus the pressure is increased.

The advantage of thus separating the pressure of the vapor from the pressure of the gaseous atmosphere, is apparent from the fact that the total pressure has two daily maxima and minima, in the explanation of which, much ingenuity has hitherto been wasted. The whole mystery is now solved by the bi-hourly observations at the English meteorological observatories. The vapor pressure and that of the gaseous atmosphere have each but one daily maximum and minimum, as might be expected from the fact that there is but one daily maximum of temperature. But the motions of the vapor and the gaseous atmosphere following different laws; and their maxima occurring at opposite hours of the day, the *sum* of their effects, or the total pressure as shown by the barometer, exhibits two daily maxima and minima, which occur at different hours from the maximum and minimum of temperature.

The following table exhibits the instances, corrected for capillarity and temperature, in which the barometer has risen above 29·25.

1841, March 17, 9 A. M.	29·320	1842, Dec. 26, 9 A. M.	29·310
" April 15, 9 A. M.	·331	1843, Jan. 17, 9 A. M.	·289
" Dec. 22, 9 A. M.	·272	" Dec. 13, 9 A. M.	·413
1842, Jan. 23, 3 P. M.	·295	1844, March 5, 9 A. M.	·294
" March 12, 9 A. M.	·262	" April 1, 9 A. M.	·324
" Nov. 29, 9 A. M.	·254	" Oct. 20, noon,	·267

The following are all the instances in which the barometer has sunk below 28·25.

1841, March 13, 9 A. M.	28·227	1843, Jan. 31, 1½ P. M.	27·961
" April 29, 3½ P. M.	27·923	" Feb. 10, 9½ P. M.	28·097
" Dec. 4, 6 A. M.	28·104	" March 28, 7⅜ A. M.	27·841
" Dec. 10, 3 P. M.	·088	1844, Jan. 12, 10 P. M.	28·070
1842, Feb. 4, 4 P. M.	·008	" Jan. 17, 9 A. M.	·150
" March 2, 3 P. M.	·244	" Oct. 15, 3 P. M.	·239
" Nov. 8, 9 A. M.	·221	" Oct. 18, 9 P. M.	·243
" Nov. 17, 7 P. M.	·091	" Dec. 22, 3 P. M.	·205
		1845, Jan. 13, 9 A. M.	·218

The entire range of the barometer for the seven years, is 1·719, from 27·841 to 29·560. The range of the barometer at Hudson is only three quarters what it is at the level of the sea in the same latitude ; that is, the barometric wave is reduced one quarter at the elevation of 1100 feet. It may hence be inferred that the great fluctuations of the barometer are confined to the lower regions of the atmosphere.

Fluctuations of the barometer, exceeding ·7 inch within 24 hours.

Date.	Barometer.	Oscillation.
1841, April 28, 9 A. M.	28·847	·777 in 24 hours.
" " 29, 9 A. M.	28·070	
" Dec. 2, 3 P. M.	28·899	·735 in 24 hours.
" " 3, 3 P. M.	28·164	
1842, Feb. 4, 4 P. M.	28·008	·783 in 17 hours.
" " 5, 9 A. M.	28·791	
" " 15, 9 A. M.	29·036	·728 in 24 hours.
" " 16, 9 A. M.	28·308	
" Nov. 29, 9 A. M.	29·254	·759 in 24 hours.
" " 30, 9 A. M.	28·495	
" Dec. 28, 9 A. M.	29·219	·768 in 24 hours.
" " 29, 9 A. M.	28·451	

Date.			Barometer.	Oscillation.
1843, Jan.	8,	9 A. M.	28·269	
" "	8,	3 P. M.	28·686	·417 in 6 hours.
" "	9,	9 A. M.	29·014	·745 in 24 hours.
" Feb.	10,	9 A. M.	28·812	·715 in 12½ hours.
" "	10,	9½ P. M.	28·097*	
" March	27,	9 A. M.	28·728	·887 in 23 hours.
" "	28,	7¾ A. M.	27·841	
" "	28,	9 A. M.	27·848	·946 in 24 hours.
" "	29,	9 A. M.	28·794	
1844, Jan.	12,	9 A. M.	28·692	·622 in 13 hours.
" "	12,	10 P. M.	28·070	
" Dec.	7,	9 A. M.	28·345	·772 in 24 hours.
" "	8,	9 A. M.	29·117	
1845, Jan.	13,	9 A. M.	28·218	·704 in 24 hours.
" "	14,	9 A. M.	28·922	
" "	17,	3 P. M.	28·450	·724 in 24 hours.
" "	18,	3 P. M.	29·174	

The greatest range in 24 hours, for the entire period of seven years, was ·946, March 28, 1843. Only four cases have occurred in which the fluctuations amounted to ·8 inch in 24 hours.

The season of the year in which these maxima, minima, and extraordinary fluctuations have occurred during seven years is shown in the following table.

	Maxima.	Minima.	Fluctuations.
October,	3	2	0
November,	5	4	1
December,	5	6	5
January,	4	5	8
February,	2	4	5
March,	5	4	4
April,	2	1	1
May,	0	2	0

* About the time of minimum, the column of mercury was very unsteady, oscillating through an arc of from ·02 to ·03 inch. This motion was not due to agitation of the tube, but to sudden changes of pressure, and resembled very much the respiration of an animal. On the 14th of August, 1843, just at the commencement of a shower the barometer oscillated through ·073 inch. Cases of this kind are not uncommon.

The most remarkable atmospheric disturbances are confined to the cold months, and are altogether unknown in summer.

THERMOMETER AND HYGROMETER.

		1841.		1842.		1843.		1844.		Mean 7 years.		
		Ther.	Hygr.	Ther.	Hygr.	Ther.	Hygr.	Ther.	Hygr.	Ther.	Hygr.	Diff.
March,	9 A. M.	36·7°	29·3°	43·3°	36·8°	25·8°	17·0°	39·2°	34·4°	37·8°	30·9°	6·9°
"	3 P. M.	46·2	31·9	51·1	33·6	34·3	20·0	45·7	37·4	46·2	33·3	12·9
April,	9 A. M.	44·3	38·1	53·1	44·0	50·0	41·0	61·1	51·1	51·5	42·5	9·0
"	3 P. M.	51·2	39·8	61·6	47·9	56·3	42·7	70 0	55·5	59·4	45·0	14·4
May,	9 A. M.	56·2	47·0	56·0	47·4	59·5	48.9	62·0	54·7	58·1	49·9	8·2
"	3 P M.	63·2	48·6	62·6	48·3	68·3	50·7	68·4	56·3	64·8	51·2	13·6
June,	9 A. M.	72·5	64·8	65·3	58·5	65·7	59·4	67·5	60·3	67·8	61·0	6·8
"	3 P. M.	78·1	66·7	71·8	59·8	71·8	62·0	73·2	62·6	73·6	63·2	10·4
July,	9 A. M.	72·3	62·6	71·1	63·9	73·2	65·4	73·8	67·8	72·9	65·9	7·0
"	3 P. M.	78·7	64·6	76·5	63·3	79·0	65·4	78·7	70·4	78·6	67·2	11·4
Aug.	9 A. M.	70·3	64·2	68·5	63·7	70·7	64·9	68·9		69·8	64·2	5·6
"	3 P. M.	77·9	66·0	74·3	64·6	76·8	66·6	73·7		76·1	66·0	10·1
Sept.	9 A. M.	64·9	62·3	61·7	58·3	65·7	62·0	62·2	60·0	61·5	58·1	3·4
"	3 P. M.	73·1	64·5	69·7	59·3	72·0	64·4	69·8	63·6	69·5	60·2	9·3
Oct.	9 A. M.	44·6	39·8	47·5	45·1	46·3	43·8	47·7	45·3	48·0	44·4	3·6
"	3 P. M.	52·7	41·1	57·4	46·1	51·1	45·8	53·4	46·7	55·4	45·9	9·5
Nov.	9 A. M.	38·8	34·9	32·7	29·1	36·1	31·6	40·2	36·5	35·6	31·7	3·9
"	3 P. M.	42·3	35·0	40·5	30·9	40·4	33·2	45·3	38·2	41·5	33·2	8·3
Dec.	9 A. M.	31·1	28·7	28·7	24·9	33·0	29·9	32·3	29·2	29·0	25·9	3·1
"	3 P. M.	35·8	29·1	33·4	25·5	36·4	31·5	35·8	31·1	33·3	26·9	6·4
Jan.	9 A. M.	31·4	26·5	30·4	26·0	26·6	23·9	33·7		28·1	23·3	4·8
"	3 P. M.	36·8	26 5	36·2	27·6	31·5	24·9	37·3		33·7	24·8	8·9
Feb.	9 A. M.	31·8	26·3	20·4	14·4	30·9	26·7	32·6		29·3	23·8	5·5
"	3 P. M.	39·7	29·0	30·1	16·5	40·5	31·7	40·9		38·1	26·1	12·0

The following table shows the average for the seasons, for seven years, to which I have added the mean degree of humidity at Hudson, Toronto and Greenwich, complete saturation being called unity.

Seasons.		Thermom.	Hygrom.	Diff'nce.	HUMIDITY.		
					Hudson.	Toronto.	Greenwich.
Spring,	9 A. M.	49·1°	41·1°	8·0°	·759	·72	·786
	3 P. M.	56·8	43·2	13·6	·629	·615	·701
Summer,	9 A. M.	70·2	63·7	6·5	·807	·76	·725
	3 P. M.	76·1	65·5	10·6	·709	·63	·635
Autumn,	9 A. M.	48·4	44·7	3·7	·879	·82	·908
	3 P. M.	55·5	46·4	9·1	·733	·715	·846
Winter,	9 A. M.	28·8	24·3	4·5	·854	·86	·941
	3 P. M.	35·0	25·9	9·1	.721	·79	·878
Year,	9 A. M.	49·1	43·4	5·7	·823	·79	·840
	3 P. M.	55·8	45·2	10·6	·697	·685	·765

Thus it appears that the humidity of Hudson is generally intermediate between Toronto and Greenwich; but Greenwich is drier than Hudson in summer, and Toronto is more humid in winter.

In order to determine the mean temperature of Hudson, we need to know the relation between the mean temperature and the 9 o'clock observation.

The temperature at 9 A. M. is 1·0° above the mean, from one year's observations at Philadelphia; it is 0·1° above the mean, from two years' observations at Toronto; 0·85° below the mean from two years' observations at Montreal; average 0·12° above the mean, from 5 years' observations. This quantity is so small that I neglect it altogether. Subtracting 0·2° for the zero error of the thermometer, we have 48·9° for the mean temperature of Hudson. The temperature of the Atlantic coast in the same parallel is 50·6°.—Difference, 1·7°—being at the rate of one degree for 642 feet elevation. From observations made in the state of New York, Mr. Coffin has deduced a decrease of 1° for 372 feet elevation.

The observations on wells, commenced in my former article, have been continued to the present time.

Date.	A.		B.	
	Depth.	Temperature.	Depth.	Temperature.
1841, August 3,	54·5 feet.	50·9°	48 feet.	50·3°
1842, February 25,	55	50·2	47	48·0
August 22,	54	51·3	46·5	50·4
1843, April 5,	55	50·1	46	47·8
August 26,	54	51·3	45·5	50·0
1844, March 21,	53·5	50·0	45	47·5
August 27,	53·0	50·8	44	49·7
Mean of three years,	54·3	50·6	46·3	49·1
Mean of six years,	54·1	50·5	46·6	49·0

The annual range of temperature of A, is 0·9°; of B, 2·3°. If we could assume that the temperature of a well was simply that of the stratum in which its springs take their origin, we could compute the depth of the springs from the annual variation of temperature. From these data, we should find that the well A was fed by springs at the depth of 42 feet, and the well B at the depth of 30 feet. In fact, however, it is plain that the change of temperature of these wells is not due to conduction, in the usual mode in which heat travels along a metallic bar, a solid rock, or dry earth, for then the maximum temperature could not occur before mid-winter; whereas, according to my former article, (p. 316,) the maximum occurs in August or September, and the minimum in January or February. It seems clear, then, that this heat must be conveyed downward by the small streams of water which filter through the soil, and are occasionally found in considerable veins. These streams start with the temperature of the surface, but are gradually robbed of it by the strata through which they pass. The range of temperature, then, at a given depth, will depend not merely upon the depth, but upon the time occupied by the water in its descent.

But the most perplexing anomaly is the constant difference, 1·5°, in the mean temperature of the two wells. It cannot be ascribed to difference of depth, for this is only 7·5 feet, and indeed the level of the water in A is about 7 feet *higher* than that in B. Can it be ascribed to the different depths of their springs? An increase of temperature of 1·5°, corresponds to a depth of about 60 feet. Admit that the springs of A come from a depth 60 feet greater than those of B; much of their heat would be lost in traversing this distance, so that the difference in the temperature of the wells would be less than 1·5. Moreover, the observed range of temperature and time of maximum indicate a free communication with the surface of the earth, which is inconsistent with the supposition of its being entirely controlled by springs at a depth of sixty feet, where the annual variation of temperature is well nigh extinct. I infer, then, that this well must have a pretty free communication with springs at a depth of perhaps 200 or 300 feet, where the mean temperature is several degrees above that of the surface; while by means of descending streams there is a communication with the surface sufficiently free to cause an annual variation of temperature above what is due to the depth of the well. This, then, is a veritable hot-spring, as much as the hot-springs of Virginia, and its high temperature is to be ascribed to the same cause.

The following table exhibits all the days in which the thermometer has fallen to zero.

1843, February 8, 4 A. M.	- - -	—0·5°
" " 16, 6⅔ A. M.	- - -	—1·7°
" " 17, 6 A. M.	- - -	—7·8°

In the winters of 1841–2, 1843–4, and 1844–5, that is, three winters out of seven, the thermometer was not observed in any instance to sink to zero.

The following table exhibits all the days in which the thermometer has risen to 90°.

1841, June 8, - -	90°	1843, July 1, -	91·3°
" July 23, - -	93	" " 17, -	92·4
" " 24, - -	90	" " 28, -	91·4
" Aug. 18, - -	90·5		

During the summers of 1839, 1840, '42 and '43, that is four summers out of seven, the thermometer did not rise to 90°. The entire range of the thermometer in seven years has been from —10·1° to 93°, = 103·1°.

The following table shows the maximum and minimum temperature of each month for the seven years.

Months.	1838.		1839.		1840.		1841.		1842.		1843.		1844.		Mean 7 years.		
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Diff.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
March,	76·1	5·8	70·3	–4·4	74·8	17·6	78·0	5·4	77·4	17·5	50·6	1·1	72·0	14·0	71·3	8·1	63.2
April,	83·5	20·2	82·3	30·4	81·5	25·2	75·0	25·2	83·6	23·5	79·6	23·0	87·2	30·0	81·7	25·4	56·3
May,			85·4	27·0	85·1	32·6	84·5	26·7	76·8	33·0	87·9	35·8	82·5	33·9	83·7	31·5	52·2
June,	87·8	51·0	81·4	46·0	86·0	39·8	90·0	45·5	83·4	35·3	88·6	32·4	84·6	39·0	86·0	41·3	44·7
July,	92·0	55·2	88·2	60·6	86·7	55·3	93·0	53·9	87·7	44·0	92·4	46·8	88·3	47·3	89·8	51·9	37·9
Aug.,	90·8	58·2	87·1	46·7	85·0	52·0	90·5	50·2	84·6	45·4	86·4	53·0	83·9	49·0	86·9	50·6	36·3
Sept.,	81·6	36·3	77·1	35·6	76·9	33·6	88·6	38·6	86·0	34·4	87·8	38·5	82·5	41·5	82·9	36·9	46·0
Oct.,	74·5	23·6	76·2	28·6	73·3	22·4	73·4	24·9	71·5	30·7	69·2	25·0	70·0	24·5	72·6	25·7	46·9
Nov.,	62·8	8·7	52·8	6·4	67·5	20·6	75·0	19·5	68·6	6·8	57·1	14·5	66·5	19·0	64·3	13·6	50·7
Dec.,	46·6	5·0	48·0	13·7	52·1	9·3	56·6	8·8	50·2	5·5	53·7	12·0	54·6	15·0	51·9	9·9	42·0
Jan.,	57·6	–2·5	47·3	–9·1	55·1	–10·1	58·8	7·0	62·2	5·5	52·7	3·0	55·5	13·0	55·6	1·0	54·6
Feb.,	62·1	1·6	68·6	9·7	50·2	0·6	62·4	8·6	53·3	–7·8	55·7	.3·0	65·7	6·0	59·7	3·1	56·6

The following miscellaneous facts may interest some readers.

	1838.	1839.	1840.	1841.	1842.	1843.	1844.	Mean.
Ground last white with snow,	April 21.	March 9.	April 1.	April 14.	Feb. 18.	April 9.	March 22.	March 27.
Plum trees in blossom,	May 4.	April 22.	" 18.	May 15.	April 9.	May 8.	April 9.	April 25.
Last flakes of snow,	" 9.	March 17.	" 27.	" 13.	June 10.	June 1.	March 30.	May 3.
Last ice,		May 14.	June 8.	" 8.	" 11.	" 2.	May 22.	" 27.
Last frost,		June 16.	" 16.	June 16.	*	July 21	June 11.	June 26.
First frost,	Sept. 3.	Aug. 29.	Sept. 12.	Oct. 1.†	*	Sept 28.	Sept. 23.	Sept. 16.
First severe frost,	" 3.	Sept. 14.	" 22.	" 1.	Sept. 23.	Oct. 5.	Oct. 8.	" 24.
First flakes of snow,	Oct. 15.	Nov. 7.	Oct. 24.	" 24.	Oct 15.	" 8.	" 27.	Oct. 21.
Ground first white with snow,	" 28.	" 7.	" 26.	" 24.	Nov. 9.	" 14.	" 27.	" 28.

* Frost every month in the year.

† Frost is said to have been seen on low grounds earlier than this.

The following table exhibits all the cases in which the thermometer has been 25° above the dew point, all occurring at 3 P. M. I have also given the interval between each of these dates and the next subsequent rain.

Date.	Ther. above hygrom.	Rain followed.
1841, March 9,	27·0°	in 18 hours.
" " 18,	31·0	4 days.
" " 19,	25·3	3 "
" April 22,	25·4	4 "
" May 16,	26·8	4 "
" Aug. 7,	25·5	16 hours.
1842, March 16,	27·3	4 days.
" " 17,	27·0	3 "
" " 29,	29·2	17 hours.
" April 1,	26·3	33 "
" " 2,	27·6	9 "

Date.			Ther. above hygrom.	Rain followed.
1842,	May	5,	26·9	7 days.
"	"	16,	27·5	22 hours.
"	June	7,	29·5	13 "
"	July	21,	25·4	2 days.
1843,	Feb.	26,	25·7	9 hours.
"	March	7,	27·5	18 "
"	"	25,	28·8	33 "
"	April	3,	25·0	18 "
"	"	11,	31·2	45 "
"	"	12,	33·9	21 "
"	"	21,	31·2	19 "
"	May	7,	25·6	3 days.
"	"	13,	25·5	15 hours.
"	"	16,	30·3	5 days.
"	"	18,	26·8	3 "
"	"	19,	28·9	57 hours.
"	"	21,	25·7	9 "
"	July	20,	26·9	4 days.
"	"	21,	26·2	3 "
1844,	April	19,	27·5	2 "
"	May	9,	25·9	2 "
"	June	12,	25·6	16 hours.

The distribution of these dry days for the seven years has been as follows:

February,	1	May,	15	August,	1
March,	13	June,	2	September,	1
April,	18	July,	3	October,	1

Making in all 55 cases, 46 of which have occurred in the spring of the year.

In 25 out of these 55 cases, rain followed in 24 hours. This will appear the more remarkable, when it is considered that the instances in question were often the driest times in the whole month. If we admit that in some instances there was no connection between the dryness and the subsequent rain, there is certainly room to suspect such a connection in other cases. Thus, April 2, 1842, when the air had become drier than at any other time during the month, rain followed in nine hours. The same happened in February, 1843. In six instances when the thermometer had risen more than 25° above the dew point, rain followed in nine hours. When we consider that such instances of dryness occur on an average only eight times in a year, we are led to infer that the dryness not only does not prevent a speedy rain, but that it may be the effect of an approaching rain, or may operate as an efficient cause to produce it. Both of these cases I conceive to be possible, and may happen in the following manner. If, as the effect of an approaching storm, distant one or two hundred miles, a strong current is forced from a higher latitude to a lower, where it is warmer, it will be rendered drier, and moreover the heat which is given out in the condensation of vapor may produce an effect at a considerable distance in advance of the storm.

The dry air may also be an efficient cause of rain in the following way. The prevalent current of the atmosphere over the United States, is from west to east. So long as the entire mass of the atmosphere moves on together with uniform velocity in this direction, we seldom if ever have rain. But if a lower stratum stands still or flows back towards the west, rain is usually the consequence. Now this reversal of the lower current may be the effect of increased pressure, or increased specific gravity of the air; that is, an unusually high barometer, an unusually cold or dry air, may be a cause of rain.

The following table exhibits all the cases for two years in which the thermometer at Greenwich was 25° above the dew point, with the hours of observation in Göttingen mean time, which is about 40 minutes in advance of Greenwich.

Date.	Hygrom.	Rain followed;
1841, April 30, 4h.	25·0°	in 2 days.
June 4, 4	26·8	1 "
" 18, 2	27·5	15 minutes.
1842, April 28, 4	27·0	5 days.
June 6, 2	31·1	7 "
" 28, 4	30·1	42 hours.
July 15, 4	26·0	3 days.
Aug. 15, 4	27·6	4 "
" 18, 4	30·7	22 hours.

Thus it appears that the atmosphere at Greenwich is less dry than that at Hudson, but it is quite remarkable that in 1841 rain followed in 15 minutes after the driest time of the whole year.

The following are the only instances in which the dew point at Hudson has risen to 80°, all at 3 P. M.

1843, July	1,	83·1°
"	16,	80·0
"	17,	81·3

The last of these cases was immediately followed by a thunder shower.

The following are the only instances in which the dew point has sunk to zero. It should be borne in mind that these observations are made only at 9 A. M. and 3 P. M. If they had been made at sunrise, the list would have been larger.

1843, February	16,	9 A. M.	−3·5°
"	17,	"	−6·0
"	"	3 P. M.	−1·2
March	23,	9 A. M.	−0·3

Some individuals whose opinions are entitled to great respect, have expressed dissatisfaction with Daniell's hygrometer. The following objections have been urged against it.

1. That the instrument is not susceptible of sufficient accuracy.
2. That the observation requires considerable time.
3. That it is not always practicable. See this Journal, Vol. XLVII, p. 19.

The first objection has weight in the hands of an unskillful person. When an excess of ether is used, and sudden cold is produced, the thermometer does not instantly indicate the cold generated, and if you note the thermometer at the instant the ring begins to form, the observation is too high. If there is a copious deposition of dew, it requires some time for it to be redissolved, and the thermometer meanwhile will rise above the dew point, so that both observations will be too high, and the result may be erroneous several degrees. But if we use barely sufficient ether to produce a visible ring of dew, one observation will be about as much below the truth as the other is above, and the mean of the two may be relied upon within a degree.

At one time I found my assistant was habitually getting a very high dew point, which excited my suspicions, and on examination I found that the ether had all distilled over into the upper ball. The bulb of the enclosed thermometer was of course left entirely insulated. The result was that he got no ring of dew, and but little depression of the thermometer. The precaution should always be observed to expel the ether into the lower ball before each observation. Very little confidence can be placed in the observations of this instrument made by an unskillful person; but with a judicious observer, I think this instrument is as much to be relied upon as any hygrometer with which I am acquainted.

The second objection is well founded, but is not very serious. It is rare that the observation requires more than three or four minutes, and the same objection lies against nearly every direct method of determining the dew point. When observations are to be made only a few times in a day, the loss of time is not great; but where hourly observations are required, I should prefer Prof. Bache's hygrometer to any thing else I have yet seen. The observation with the wet-bulb hygrometer is very expeditiously made; but this furnishes the dew point only by *computation*, and the computation is as laborious as the observation with Daniell's hygrometer.

The third objection may be true for some climates, but I doubt if it be so for any part of the United States. Daniell's hygrometer has been observed at Hudson for seven years, every day at 3 P. M., and the experiment has never failed. Twelve times the dew point has been more than 30° below the temperature of the air, and once the difference amounted to 36°. It is doubtful whether the difference would ever be found much greater for any part of the United States. In the hands of many observers the experiment would fail at such times. It can only succeed with the aid of good ether and dextrous management. Most of the ether of commerce is unfit for the purpose, and can be used advantageously only after distillation or washing. With the best ether I could command, I have sometimes found all the contents of the lower ball distilled over into the upper, without the deposition of dew. In such a case, I immediately invert the instrument, and drive back the ether into the lower ball, and repeat the operation before the thermometer has had much time to rise. Without this precaution the experiment would sometimes have failed. The wet-bulb hygrometer has a seeming advantage over Daniell's in this respect that you can easily get an observation. This is a method well deserving attention, yet its theory can hardly be considered as sufficiently settled to entitle it to the same confidence as a direct method of getting the dew point.

In the observation with Daniell's hygrometer I have often noticed the following curious fact. As ether is applied, the thermometer sinks pretty uniformly until it approaches near the dew point, when it experiences an apparent resistance to further depression, refuses to sink any lower, and perhaps begins to rise; but if you add ether sufficient to carry it below this point, it will probably sink several degrees at a jerk. The explanation I suppose to be the following. As the lower ball is cooled down nearly to the dew point, precipitation commences, though not perhaps in a visible ring. Heat is liberated which opposes the further depression of the thermometer, and more ether is required to counteract this effect. When this obstacle is overcome, the thermometer suddenly sinks several degrees.

It will be observed that the diurnal range of the hygrometer is very small; less than 2° from 9 A. M. to 3 P. M. for the entire year. On clear nights the thermometer usually sinks to the dew point of the preceding day, and not much lower, for the liberated heat from the condensed vapor opposes its further descent. Here then we have a method of predicting the lowest temperature of the succeeding night if it be clear; and this remark may be of considerable practical utility at times when vegetation is liable to be injured by frost. If the hygrometer sinks to 40°, we may confidently expect frost in a clear and still night, although the thermometer of the preceding day may have been quite high; but as long as the hygrometer is high, there is little danger of frost.

WINDS.

The following table is constructed in the manner described in my former article, p. 320, and exhibits the results of seven years' observations.

Months.	9 A. M.					3 P. M.				
	N.	S.	E.	W.	Course.	N.	S.	E.	W.	Course.
March,	132·3	94·4	85·4	230·2	N. 75° 20′ W.	173·1	93·4	68·7	270·7	N. 68° 28′ W.
April,	128·5	107·5	99·9	200·4	78 12	203·6	108·0	69·6	234·0	59 50
May,	113·7	102·6	91·8	227·4	85 19	202·4	108·0	67·8	243·3	61 44
June,	110·1	133·2	63·8	226·1	S. 81 55	176·5	130·8	52·3	251·6	77 6
July,	112·2	97·9	66·8	224·4	N. 84 50	215·2	92·7	37·0	265·0	61 45
August,	118·0	103·4	92·2	192·0	81 41	207·5	86.0	68·2	205·0	48 24
September,	91·5	133·1	86·1	197·6	S. 69 33	165·9	123·1	68·0	230·4	75 15
October,	81·8	132·1	65·6	233·3	73 19	125·7	123·6	49·1	284·1	89 29
November,	60·0	121·5	65·7	237·0	70 14	81·5	105·6	57·5	249·9	S. 82 52
December,	94·9	122·6	72·6	278·8	82 20	124·3	113·6	65·2	281·5	N. 87 11
January,	93·7	153·2	73·9	252·2	71 32	111·3	140·8	58·4	285·0	S. 82 34
February,	90·4	124·2	57·1	243·2	79 41	117·4	133·3	38·4	283·3	86 17
Year,	1227·0	1425·8	921·1	2742·7	S. 83° 46′ W.	1904·2	1359·0	700·1	3083·8	N. 77° 7′ W.

Sum of 9 A. M. and 3 P. M.—

N.	S.	E.	W.	Course.
3131·3	2784·8	1621·2	5826·5	N. 85° 17′ W.

This result is almost identical with that of the first three years. The average wind at 9 A. M. is southerly; at 3 P. M. is northerly. The average for both hours is northerly. Considering that each of the individual years furnishes nearly the same result, there can be little doubt that at Hudson the mean progress of the wind is from northwest to southeast. If any one should regard this conclusion as doubtful, it is probable that he would not be satisfied with any thing short of the record of a self-registering anemometer. I am not aware of more than two instruments of this kind on this continent which have been observed long enough to furnish important results. These are at Toronto and Philadelphia. The following is the result of the Toronto observations for two years.

	N.	S.	E.	W.	
1841,	1832·6 lbs.	747·4 lbs.	957·2 lbs.	1741·4 lbs.	N. 35° 51′ W.
1842,	2544·4	1293·3	1386·2	2697·4	46 21
Sum of two years,	4377·0	2040·7	2343·4	4438·8	N. 41° 53′ W.

The northerly motion is here so predominant as to leave no doubt of the average progress of the wind. We shall look with interest for the publication of the Philadelphia observations.

CLOUDS.

The following table exhibits the progress of the clouds, each observation being resolved in the direction of the cardinal points. The table contains the sum of the observations for seven years.

Months.	9 A. M.					3 P. M.				
	N.	S.	E.	W.	Course.	N.	S.	E.	W.	Course.
March,	43·4	33·6	17·9	97·5	N. 83° 0′ W.	38·0	31·7	15·1	110·8	N. 86° 13′ W.
April,	35·1	39·9	16·5	90·4	S. 86 17	39·6	38·1	10·6	102·4	89 4
May,	33·2	37·3	14·2	98·4	87 11	33·3	41·4	15·5	115·9	S. 85 24
June,	50·0	49·4	10·7	116·4	N. 89 40	40·5	48·0	13·1	134·5	86 30
July,	55·6	36·1	11·2	118·8	79 44	58·1	46·6	13·2	133 8	N. 84 31
August,	64·8	45·4	20·5	109·6	N. 77 40	60·6	60·0	30·2	113·2	89 37
September,	47·3	36·0	20·7	94·1	81 15	42·8	46·8	21·6	105·3	S. 87 17
October,	48·7	49·8	11·2	118·6	S. 89 23	47·4	40·1	8·8	127·2	N. 86 28
November,	40·6	54·1	20·3	114·7	81 50	39·1	57·0	13·4	125·9	S. 80 58
December,	40·8	48·2	20·7	125·3	85 59	40·9	50·4	15·5	127·6	85 9
January,	36.3	57·8	11·7	131·6	79 50	33·8	63.4	10·9	136·3	76 44
February,	33·9	43.1	8·7	126·8	85 31	33·1	44·8	5·7	129·5	84 36
Total,	529·8	531·0	184·3	1342·2	S. 89° 57′ W.	507·3	568 2	173·6	1462·4	S. 87° 18′ W.

The mean result derived from seven years' observations does not differ half a degree from the result of the first three years.

The following table exhibits the proportion of the different varieties of clouds, the number under each month being the sum of the observations for seven years.

Months.	9 A. M.						3 P. M.					
	Cirrus.	Cumulus.	Stratus.	Cirro-cumulus.	Cirro-stratus.	Cumulo-stratus.	Cirrus.	Cumulus.	Stratus.	Cirro-cumulus.	Cirro-stratus.	Cumulo-stratus.
March,	19	10	76	8	23	32	17	27	64	16	12	39
April,	12	23	59	9	28	31	14	32	45	11	17	51
May,	10	24	38	8	22	52	6	40	24	13	28	61
June,	24	37	42	17	26	33	18	67	29	14	21	40
July,	23	55	30	21	20	26	15	93	23	16	20	31
August,	25	58	37	22	20	23	12	100	31	25	6	32
September,	22	31	43	8	23	35	7	56	30	14	15	53
October,	16	22	61	16	25	42	25	35	64	7	20	33
November,	10	14	93	4	21	47	10	19	83	13	22	48
December,	6	4	129	3	21	39	5	4	115	5	23	48
January,	5	6	106	7	32	39	6	11	93	10	30	48
February,	12	5	78	12	31	38	15	18	71	10	26	38

The following table exhibits the clouds of the seven years arranged by seasons.

Seasons.	9 A. M.						3 P. M.						Sum of both hours.					
	Cirrus.	Cumulus.	Stratus.	Cirro-cumulus.	Cirro-stratus.	Cumulo-stratus.	Cirrus.	Cumulus.	Stratus.	Cirro-cumulus.	Cirro-stratus.	Cumulo-stratus.	Cirrus.	Cumulus.	Stratus.	Cirro-cumulus.	Cirro-stratus.	Cumulo-stratus.
Spring,	41	57	173	25	73	115	37	99	133	40	57	151	78	156	306	65	130	266
Summer,	72	150	109	60	66	82	45	260	83	55	47	103	117	410	192	115	113	185
Autumn,	48	67	197	28	69	124	42	110	177	34	57	134	90	177	374	62	126	258
Winter,	23	15	313	22	84	116	26	33	279	25	79	134	49	48	592	47	163	250
Total,	184	289	792	135	292	437	150	502	672	154	240	522	334	791	1464	289	532	959

The cumulus is the prevalent cloud of summer, the stratus is most common throughout the remainder of the year.

The following table exhibits the average cloudiness of the different months, according to seven years' observations. 0 represents a sky perfectly clear, 10 entirely overcast. For comparison I have added the results of three years' observations at Cambridge, and two years' at Greenwich.

Months.	Hudson.		Cambridge.				Greenwich.	
	9 A. M.	3 P. M.	Sunrise.	9 A. M.	3 P. M.	9 P. M.	9 A. M.	3 P. M.
March,	6·8	6·6	5·1	5·6	6·6	5·9	6·4	6·5
April,	5·5	5·9	5·8	5·9	5·6	5·7	6·5	5·4
May,	5·9	6·6	5·3	5·5	5·9	5·2	6·0	6·6
June,	5·7	5·9	5·2	4·6	5·7	5·0	6·2	6·0
July,	4·9	5·3	4·4	4·2	4·2	3·6	7·3	7·6
August,	5·2	5·8	6·3	6·3	5·7	5·5	6·1	5·5
September,	5·2	5·6	5·3	5·1	5·1	4·4	6·8	6·5
October,	6·1	6·2	4·3	4·5	5·0	3·9	6·6	7·4
November,	7·7	7·7	4·7	5·1	5·6	4·5	8·0	7·1
December,	8·6	8·4	6·3	6·4	6·7	5·9	7·1	7·1
January,	7·7	7·7	4·9	5·6	5·4	4·4	7·7	7·2
February,	7·4	7·1	5·0	5·4	5·4	5·6	8·6	7·1

The following table exhibits the same observations arranged by seasons.

Seasons.	Hudson.		Cambridge.				Greenwich.	
	9 A. M.	3 P. M.	Sunrise.	9 A. M.	3 P. M.	9 P. M.	9 A. M.	3 P. M.
Spring,	6·0	6·4	5·4	5·7	6·0	5·6	6·3	6·2
Summer,	5·3	5·7	5·3	5·0	5·2	4·7	6·5	6·4
Autumn,	6·3	6·5	4·8	4·9	5·2	4·3	7·1	7·0
Winter,	7·9	7·8	5·4	5·8	5·8	5·3	7·8	7·1
Year,	6·4	6·6	5·2	5·4	5·6	5·0	6·9	6·7

We perceive that the cloudiness of Hudson is much greater than that of Hanover or Cambridge, at every season of the year. It is greater than that of Greenwich in winter, and is but slightly inferior for the remainder of the year.

From Dec. 14, 1839, to Jan. 15, 1840, a period of 33 days, the sky was not free from clouds in a single instance at a regular hour of observation. From Aug. 10, 1844, to Sept. 14, a period of 36 days, the same was true; and from July 27 to Sept. 14, a period of 50 days, the sky was cloudless but once at a regular hour of observation. From Nov. 23, 1841, to Dec. 31, a period of 39 days, the sky was never cloudless; and from Oct. 29 to Dec. 31, a period of 64 days, the sky was cloudless but once at a regular hour of observation, and during this period, the obscuration was generally total. It will be remembered that the sky is called cloudless, when the clouds cover less than one tenth of the visible heavens. Of all the places with which I am acquainted, Hudson is during the winter months the most cloudy.

RAIN.

The following table shows the amount of rain for each month of four years, and the average for seven years. The numbers for 9 A. M. show the amount fallen since the preceding 3 P. M.

Months.	1841.		1842.		1843.		1844.		Average 7 years.		
	9 A. M.	3 P. M.	9 A. M.	3 P. M.	9 A. M.	3 P. M.	9 A. M.	3 P. M.	9 A. M.	3 P. M.	Total.
March,	2·611	·170	2·511	1·020	1·207	·092	2·645	·596	2·577	·696	3·273
April,	1·941	·464	3·447	·554	·910	·802	·690	·599	1·632	·692	2·324
May,	1·490	·089	1·148	·653	1·375	·358	4·027	·515	2·186	·536	2·722
June,	1·716	1·375	2·170	·291	5·246	·296	4·699	·784	3·409	·965	4·374
July,	1·131	·170	3·979	·931	1·397	·044	2·305	·187	2·106	·558	2·664
Aug.	1·350	·615	3·128	2·543	1·963	1·333	4·721	1·666	2·495	1·371	3·866
Sept.	1·205	·531	2·957	·126	2·247	·852	1·247	·750	2·062	·647	2·709
Oct.	1·188	·707	2·336	·342	1·593	·513	1·300	1·644	1·572	·717	2·289
Nov.	2·235	1·302	1·366	·197	1·609	·790	·449	·700	1·690	·714	2·404
Dec.	2·690	1·029	1·036	1·187	1·595	·559	1·536	·239	1·551	·493	2·044
Jan.	·999	·150	1·290	·712	·816	·231	1·264	1·104	1·226	·483	1·709
Feb.	3·135	·138	·916	1·274	·769	·139	1·536	·527	1·708	·693	2·401
Year,	21·691	6·740	26·284	9·830	20·727	6·009	26·419	9·311	24·214	8·565	32·779

The following table shows the average fall of rain for the different seasons.

	9 A. M.	3 P. M.	Sum.
Spring,	6·395	1·924	8·319
Summer,	8·010	2·894	10·904
Autumn,	5·324	2·078	7·402
Winter,	4·485	1·669	6·154

The following table shows the amount of snow in inches for each month of the seven years.

Months.	1838–39.	1839–40.	1840–41.	1841–42.	1842–43.	1843–44.	1844–45.	Mean.
October,	3·5		0·5	2·5		2·5	10·	2·7
November,	7·5	9·	3·	11·5	13·	5·	1·	7·1
December,	5·5	12·	16·	9·	7·5	2·5	9·	8·8
January,	5·	8·	9·5	5·5	5·	5·5	7·	6·5
February,	8·5	1·5	5·	3·5	17·5	7·5	8·5	7·4
March,	4·	3·	14·5		6·	6·5	26·	8·6
April,		3·5	4·		0·5		1·	1·3
Year,	34·	37·	52·5	32·	49·5	29·5	62·5	42·4

March 7, 1841, seven inches of snow lay on the ground; March 13, 6·5 inches of new snow fell, and during the two or three subsequent days there was a slight increase, making *thirteen* inches on the ground at one time, the greatest depth I have ever seen in Hudson. It is said to have been the deepest snow known since Feb. 1818, when it was about twenty inches on a level. In Dec. 1811, the snow is said to have fallen two feet deep.

The following are all the instances in which an inch of rain has fallen in 24 hours.

Date.	Amount.	Time.	Date.	Amount.	Time.
1842, Feb. 4,	1·564	18 hours.	1843, June 5,	1·940	12 hours.
" March 5,	1·112	20 "	" " 15,	1·944	12 "
" July 9,	1·153	24 "	" Aug. 17,	1·095	5 "
" " 30,	1·491	18 "	" " "	1·458	9 "
" " "	1·649	20 "	" Sept. 14,	1·079	15 "
" Aug. 26,	1·662	6 "	1844, June 2,	1·285	9 "
" " "	2·503	24 "	" " 17,	1·248*	5 "
" " "	3·170	36 "	" Aug. 28,	2·779	27 "
" Sept. 3,	1·285	3 "	" Sept. 29,	1·092	24 "
			" Oct. 30,	1·085	18 "

* Of this quantity, ·935 inch fell in about fifteen minutes.

Art. V.—*On the Physical Geology of the United States east of the Rocky Mountains, and on some of the Causes affecting the Sedimentary Formations of the Earth;* by William W. Mather, Professor of Natural Sciences in the Ohio University, Athens, Ohio.

(Continued from page 20 of this volume.)

Part II. *On the Causes of Elevation of the Sedimentary Rocks above the Level of the Sea.*

In the first part of this paper, I have treated very concisely of the effects that would flow from the refrigeration of the earth as a heated body, and the influence of the rays of the sun in producing, maintaining and occasionally modifying the great equilibrating currents of the ocean, that, by their long continued action, have caused the transport and deposition of the materials of the sedimentary rocks of the United States.

It is now purposed to treat of the *causes* by which these rocks may have been raised above the level of the sea.

The sedimentary rocks are generally found to contain an abundance of the remains of marine animals, so perfect, that we feel constrained to infer that they must have lived and died and been buried where we now find them. Those rocks, often of great thickness, cover extensive areas of the earth's surface, and must at some time have been the bed of the sea. Here the animals whose remains we find once lived, and their relics were buried beneath oceanic deposits, each of which was successively the bottom of the ocean. The relative levels of the continents and of the ocean must have changed, and one of two conclusions follows, viz. the ocean must have sunk below its former level and exposed the land, or the continents have been raised and made to emerge from the ocean.

It is not probable that there is less water on the surface of the earth at present than at any preceding time; for we know of no cause by which it could have disappeared, except by decomposition and its elements combining with other bodies; and there is no body or class of bodies known that contains hydrogen sufficient in quantity, if converted into water, to cause an increased elevation of level of one foot, or even one inch, over the ocean. Hence we infer that the relative variations of the level of the ocean is *not* due to the disappearance of water.

The ocean being a fluid, maintains its equilibrium and retains its level, and we have no alternative but to admit, that the solid ground has been elevated above its former level, and also that the surface of the earth has not all the stability that is usually assigned to it.

These conclusions are conformable to observations during the historical epoch, and also to the philosophical deductions from known dynamical causes, and from the facts observed among the solid strata of the globe.*

Various causes have been assigned for the elevation of land above the level of the sea, beneath which it was once buried, as follows, viz.

1st. Volcanic agency, by the aid of highly elastic steam and gases.

2d. Unequal contraction of water and land by a diminution of the mean temperature of the earth.

3d. An undulatory action of the fluid interior of the earth, combined with a lateral tangential force.

4th. The contraction of the earth by secular refrigeration, and the solid exterior collapsing upon the fluid interior, and being too large to embrace it closely, causes plications and bending of the strata, depressing some parts below the general level, and elevating others by lateral thrust.

The first of these causes, viz. that of volcanic action, may be considered as one of the effects of a more general cause, and to which the elevatory movements may also, independently, be ascribed.

The second, viz. that of unequal contraction of land and water by a diminished mean temperature of the earth, may be supposed to have a different result from that intended to be explained; because, though water contracts more than solids for equal diminutions of temperature, yet the thickness of the solid part of the

* The coast of Sweden is gradually rising above the level of the sea; that of Greenland is gradually sinking; the coast of Chili was suddenly elevated during an earthquake in 1822; the repeated elevation and subsidence of the Temple of Serapis, on the shore of the Mediterranean, are all considered well authenticated facts, and demonstrate these variations in the level of the land without the necessity of adducing any of the numerous and well known effects of volcanic agency in producing elevation and subsidence. From recent observations it is also rendered highly probable that an area of 4,000,000 square miles is gradually sinking lower and lower in the Pacific Ocean.

globe may be supposed so much greater than the mean depth of the ocean, that the contraction of the solids would be greater than that of the water, so as to produce the effect of a rise of water with reference to the land. And again, for another reason, viz. the diminution of the temperature of the land and water independently of the consideration of the relative masses, through the whole range of temperature from boiling to freezing water, would be entirely inadequate to account for the apparent diminution in the level of the ocean, even if its mean depth was much greater than it is.

The third cause, viz. that of an undulatory motion of the fluid interior of the earth, combined with a lateral tangential force,* harmonizes with many of the facts that have been observed. It will be discussed in another place.

The fourth cause, viz. that of the secular refrigeration of the globe, is that usually adopted, and it seems to accord and harmonize with the facts known.

The numerous investigations on the temperature of the earth at the various depths to which man has penetrated by mining, and by boring for salt wells and Artesian springs in different countries, have established the fact, that the earth becomes warmer as the depth increases, at the rate of one degree of Fahrenheit's thermometer for forty-five to sixty-five feet in depth. If the temperature increases in the same proportion toward the centre of the earth,† the rocks at no great distance below the surface would be in a melted state.

The form of the earth is also found to be such as would be the form of equilibrium of a fluid body revolving with the velocity of the earth.

The varied mathematical researches of Cordier, Fourier, Poisson and Svanberg upon the refrigeration of heated bodies, the temperature of the earth and of space, tend to show that the earth is in a cooling state, and that it radiates into space more caloric than it receives from the sun, although it has reached what may be called an asymptotic condition.

M. Fourier has shown that the radiation of the earth must have been such in times past as to reduce the temperature of the exte-

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* Vide Prof. Rogers's paper, Transactions of the Association of American Geologists and Naturalists, Vol. I.

† It really increases more rapidly at increased depths.

rior more rapidly than the interior, and that this external diminution has nearly reached its limit, so that the caloric radiated by the earth exceeds that derived from the sun and from space by a quantity sufficient to melt about three metres in depth (about ten feet) in one hundred years.* This diminution of temperature would progress most rapidly in a decreasing ratio up to a certain limit, after which the internal temperature would begin to diminish most rapidly, while the exterior remained nearly uniform.

Three reasons may be adduced why the interior should diminish more in temperature after the above-mentioned limit is passed, viz.

1st. The more imperfect conducting power of the solid exterior, than the carrying power of the fluid interior.

2d. The solid exterior having parted with a portion of its caloric, serves to conduct merely the excess of interior heat to the exterior, whence it radiates into space; and this quantity radiated and conducted is nearly uniform, and maintains a temperature nearly uniform in the exterior crust of the globe, while the interior may undergo great variations.

3d. The surface from which the radiation takes place, is greater than the surface of any contained spherical mass from which it draws its caloric for radiation.

The earth is in a state of nearly uniform exterior temperature so far as internal heat is concerned, and while the exterior solid part of the earth undergoes little change in its bulk from loss of temperature, the interior is gradually diminishing, causing collapse of the solid exterior upon the fluid interior; and in consequence of this solid part being too large to embrace the nucleus closely, elevation of islands, mountains and continents in some parts, and subsidence to a still greater extent in other parts, would seem to be the necessary consequences.

In the other case, where the crust or exterior solid part cooled and shrunk most rapidly, it may reasonably be supposed to have cracked open in fissures, and the subjacent fluid to have risen in the fissures to a height inversely proportioned to its density, as water does in the cracks of ice. This supposition, which seems a necessary result from the known laws of nature, harmonizes

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* Baron Fourier, Annales de Chimie et de Physique; also a translation of a part of the above memoir in the American Journal of Science, Vol. XXXII, pp. 1–19.

with the abundance of trappean and other unstratified rocks, the quartz and other veins, and their effects in producing metamorphic changes on the adjacent masses, during the epochs of the earlier fossiliferous deposits.

We may admit that the earth is in the state of a cooling body, far warmer in its mean temperature on its surface than the regions of space in which it moves around the sun, although long, very long periods of time make no appreciable difference in its mean temperature.*

If the earth be a cooling body, it must have diminished in volume, in obedience to the law that bodies contract by diminished temperature, and expand by heat.

If the earth has diminished in volume, it has increased in its velocity of rotation, (in obedience to a well known dynamical law.) This would tend to shorten the length of the day, and it has been shown by La Place, that for two thousand years at least the length of the day, or of a revolution of the earth on its axis, has not varied $\frac{1}{300}$ of a centesimal second.†

It might here be said that this is sufficient evidence that the earth has not contracted, and that no geological effects have been produced, dependent on such a cause.

It may be said in answer:

1st. The rate of cooling and consequent contraction is extremely slow, and long periods would be required to make it manifest.

2d. The effects of the contraction in the production of currents in the ocean, and the sedimentary deposits from them, and the effects on the rocks themselves, lead to the conclusion that the changes of volume were *paroxysmal* rather than secular; that a gradually accumulating tension was finally overcome by a sudden yielding of the solid strata, producing earthquakes and undulations of the surface, an increased velocity of rotation on the earth's axis, an increased flow of the equilibrating currents of

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* The Baron Fourier has given the following as the law of the diminishing temperature of the earth. The diminution is equal to the present mean temperature divided by double the number of centuries since the cooling process commenced. He concludes that since the time of the Greek school at Alexandria, the mean temperature has not varied from loss of radiant heat $\frac{1}{300}^{\circ}$ of the Centigrade ($\frac{1}{540}^{\circ}$ Fahrenheit's) thermometer.—*Am. Jour. Sci. Vol. XXXII, p.* 16.

† This conclusion was deduced by calculating backwards the times of eclipses that were registered in Ptolemy's Almagest, and observed in the time of Hipparchus.

the ocean in consequence of the inertia and increased centrifugal force, requiring an increased protuberance in the spheroidal form of the earth to restore the form of equilibrium to the revolving spheroid.

The changes in the times of rotation of the earth being supposed paroxysmal, occurring at particular periods of time, and none of these having occurred during the historical epoch, (unless the time of the deluge was one of them,) the argument from the fact that the length of the day has not varied for two thousand years loses all its force, and cannot be adduced in opposition to the views here advocated.

3d. It is well known that the angular velocities of a revolving spherical body under varied diameters, are inversely proportioned to the squares of the radii,* so that if the earth be a cooling body,

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* Vide M. Poisson's Mecanique, second edition, Tome II, p. 460, and American Journal of Science, Vol. XLVI, p. 344–346.

The angular velocity of a revolving body is represented by the well known formula $\omega = \frac{MRv}{\Sigma(mr^2)}$, (Young's Mechanics, American edition, p. 193,) which is equal to the moment of applied force divided by the moment of inertia. $\Sigma(mr^2) = mk^2$, (Young's Mechanics, Am. ed., p. 190,) in which k represents the radius of gyration, and m the mass of the revolving body. By substitution $\omega = \frac{MRv}{mk^2}$. In the revolving sphere with a variable radius, the quantity of matter remaining constant $M = m$, and as R and v are constants, $\omega \propto \frac{1}{k^2}$. In the sphere $k^2 = \frac{2}{5}r^2 \therefore \omega \propto \frac{1}{r^2}$ and $\omega' \propto \frac{1}{r'^2} \therefore \omega : \omega' :: \frac{1}{r^2} : \frac{1}{r'^2}$ or the angular velocities vary inversely as the squares of the radii.

If the variable density due to variable volume be considered, the law of the angular velocities being inversely as the squares of the radii still holds true; for, in the sphere $mk^2 = \frac{4}{3}\pi r^3 \times \frac{2}{5} r^2$ when the density is unity. When the density is D, the moment of inertia is $= D \times \frac{4}{3}\pi r^3 \times \frac{2}{5} r^2$ and $\omega = \frac{MRv}{D \times \frac{8}{15} r^5}$. Calling D' the density in the second place and r' the corresponding radius $\omega' = \frac{MRv}{D' \times \frac{8}{15} r'^5}$; hence $\frac{\omega}{\omega'} = \frac{D'}{D} \times \frac{r'^5}{r^5}$. But the mass being constant, the densities are inversely proportioned to their volumes, or $\frac{D'}{D} = \frac{V}{V'}$. Substituting this value, we obtain $\frac{\omega}{\omega'} = \frac{V}{V'} \times \frac{r'^5}{r^5}$, and by substituting for V and V′ their values in terms of the radii, we obtain $\frac{\omega}{\omega'} = \frac{r^3}{r'^3} \times \frac{r'^5}{r^5} = \frac{r'^2}{r^2} \therefore \omega : \omega' :: \frac{1}{r^2} : \frac{1}{r'^2}$. (This last demonstration was communicated by Lieut. Roberts, Assistant Professor of Natural Philosophy, West Point, N. Y.)

and if it has diminished in volume, it must have increased in its velocity of rotation, and produced greater velocities in the great equilibrating currents of the ocean.

M. Pontecoulant, after going into an analytical investigation of the disturbing action of the sun, moon and planets upon the earth, deduces the conclusion that the action of those bodies upon the terrestrial spheroid will never produce any appreciable displacement in the position of its poles on its surface, nor any sensible variation in the quickness and uniformity of its motion of diurnal rotation, which, he remarks, are important results and insure forever the stability of terrestrial latitudes, and invariability in the length of the day.*

The equation of the mean day† reduced to time, estimating the circumference as equal to one day, amounts to a period of only a few minutes in several millions of years, and it is unnecessary for astronomers, says La Place, to notice it.‡

M. Poisson in his Mechanics, speaking of the diminution of the volume of the earth and of the shortening of the day, says, "A diminution due to this cause of one ten millionth part of a day, would suppose a decrease of one twenty millionth part of the length of the radius; and as we are certain that the day has not experienced this diminution for twenty-five hundred years, it follows that the mean radius of the earth has not varied three metres during this long interval of time by the effect of cooling, if the mean temperature of the earth has not yet arrived at a permanent state."§

So far as I have ascertained, philosophers have not considered the effect of centrifugal force, by an increased velocity of rotation of the earth. In an article in the American Journal of Science, Vol. XLVI, pp. 344–346, on the possible variation in the length of the day, I suggested that there might be compensating forces that would tend to maintain the time of rotation uniform, and the day unchanged in length, even if the earth be undergoing a slight change in its dimensions, either secularly or paroxysmally.

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* Pontecoulant, Théorie Analytique du Systême du Monde, T. II, p. 224.

† The formula for calculating this is given by La Place, and the value above mentioned, when calculated approximatively by a method indicated in the Mecanique Celeste, (Bowditch's translation, Vol. II, pp. 855 and 867, 3152 *b* to *f*,) gives a variation of about one centesimal second in a thousand years.

‡ Mecanique Celeste, translated by Bowditch, Vol. II, p. 867.

§ Poisson's Mecanique, T. II, 460.

The centrifugal force is one of these compensating causes. It varies inversely as the *cubes* of the radii* of a sphere whose volume varies while its mass remains constant, but the angular velocities vary inversely as the *squares* of the radii; hence, if the earth should contract in volume, the velocity of rotation would necessarily increase in obedience to the law of conservation of areas; but the centrifugal force would be increased in a still higher ratio, and would cause a flow of water from the polar towards the equatorial regions to give the form of the spheroid of equilibrium, and would thus tend to diminish the increase of velocity due to contraction.

It necessarily follows from what precedes, that the argument in reference to the day having remained uniform for twenty five hundred years, has not as much weight as has been assigned to it, and ought not to be adduced as demonstrating that the earth is not in the state of a cooling body, or that it has not diminished in volume, or that no geological effects can be ascribed to this cause.

Even if it be admitted that the uniformity in the length of the day for twenty five hundred years should have weight and render it improbable that there has been any contradiction during that time, and if in addition we discard even the compensating effect of increased centrifugal force in tending to maintain uniformity in the length of the day; yet the period of twenty five hundred years may be considered as only the differential of the long periods of past duration, during which the geological effects we have contemplated were produced.

Still another argument may be adduced, viz. that the variations in the rapidity of rotation took place paroxysmally, at certain periods, generally at long intervals of time, and that none of these variations have occurred during the historical epoch, unless the time of the deluge was one of them.

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* $\left.\begin{array}{l}\omega : \omega' :: \frac{1}{r^2} : \frac{1}{r'^2} \\ t : t' :: r^2 : r'^2\end{array}\right\}$ but $F : F' :: \frac{r}{t^2} : \frac{r'}{t'^2}$ $\therefore F : F' :: \frac{r}{r^4} : \frac{r'}{r'^4} :: \frac{1}{r^3} : \frac{1}{r'^3}$. Hence the centrifugal forces represented by F and F′ vary inversely as the cubes of the radii, and the increment of centrifugal force $F - F' = F\frac{(r^3 - r'^3)}{r'^3}$ would tend continually to diminish ω by increasing r, and thereby tend to make t (which represents the time of rotation) constant.—(Communicated by Prof. A. Ryors, of the Ohio University.)

The evidences that the periods of variation in the angular velocity of the earth were paroxysmal are threefold, viz.

1st. The strata of sedimentary rocks show alternations of strata, entirely different in composition and texture, lying directly contiguous upon each other, with no intermediate blending of their materials; as for example, a bed of fine slate or of limestone, which must have been formed in nearly tranquil water, is immediately succeeded by a coarse sandstone or a conglomerate, which must have required a strong current to transport its fragments, and currents of variable velocities would be a necessary result of paroxysmal changes in the volume of the earth.

2d. Local examples have been observed where the strata that had been formed up to a certain period, (as, for example, that of the Helderberg limestone,) have been broken up and turned on their edges over a large area; and succeeding this, a period of repose supervened, during which rocks were deposited in nearly horizontal strata *unconformably* on the upturned edges of those in the disturbed district, while the same strata were deposited *conformably* in the adjoining undisturbed districts, with no rocks of intermediate age intervening. In both cases the rocks are of the same kinds, have the same characters, and contain the same fossils.

3d. The folded axes of the mountain chains of the eastern parts of the Uuited States, in which the strata have been elevated in wrinkles and folds, all of which, when elevated at a high angle, have fallen over in a westward direction, giving an eastwardly dip. Paroxysmal elevation and the action of inertia, offer a satisfactory explanation of the folded axes and eastwardly dip. Had the elevation been secular, like that of the coast of Sweden, (where it has been perceptible only in a long course of years until in 1843, when there was a sudden though moderate elevation,) the difference in the linear velocities at the different distances to which the masses were elevated in the course of ages, would be too small to cause the inertia to produce any sensible effects; but in the other case, suppose the *sudden* elevation of a mountain mass one mile in height, or more distant from the axis of rotation than it was before its elevation. It would still retain the linear velocity it had when a mile nearer the axis of rotation, while the *proper* linear velocity at this increased distance would be $\frac{3 \cdot 1415}{24}$ miles, or 694 feet greater per hour, than that which it had before its elevation. Inertia, therefore, would cause the mass at the top, to press to the westward with a force proportional to its mass, and the above mentioned velocity, and at intermediate heights with a proportionably less momentum. If the strata be capable of yielding, they must, when elevated in highly curved wrinkles, tend to fall over to the westward, as a consequence of the influence of inertia and the revolution of the earth from W. to E. on its axis.

We have reason to believe, both from the action of natural laws and from observation, that the aggregate amount of subsidence, or of contraction of the mass of the earth, at least equals, if it does not exceed the amount of elevation above former water levels. The evidences above adduced of variable currents depositing strata of various textures and composition; of conformable and unconformable strata of the same ages; and the influence of inertia and the rotation of the earth producing the folded axes with an eastwardly dip, all tend to render it more than probable, that the secondary causes of the phenomena were paroxysmal rather than secular, and that they occurred at distant intervals of time, with long periods of comparative repose.

It has already been remarked, there are no evidences known, that there has been more water upon the surface of the earth at any preceding time than at present.* It follows from the various facts known, that the relative levels of the land and water have changed and the land must have been elevated, or the bed of the ocean must have sunk, or that both these effects have been more or less extensively produced.

The only causes to which we can ascribe such relative changes of level that have not yet been considered, are,

1st. Some subterranean force tending to elevate parts of the earth's surface.

2d. The collapse of the crust of the globe by a secular refrigeration upon its contracted nucleus, causing depression in some parts and elevation in others.† The powerful lateral thrust, that would be caused by a subsidence of the solidified crust upon a contracted nucleus which it is too large to envelope closely, would cause an elevation of some parts, with wrinkles and plications of the strata, and may be supposed to be amply sufficient to elevate

* See p. 284, *ante*. † See p. 287.

mountains, mountain chains and continents, and produce all the phenomena of contortion, wrinkling, folding and crushing of the strata, that are so strikingly exhibited in the eastern parts of the United States.

That both the causes above stated have acted in times past, and will continue in time to come, can scarcely be doubted. The phenomena of both these causes necessarily follow from the refrigeration of the globe. Subsidence of parts of the earth's crust may, and probably have caused extensive elevation of others; but we know of no *other* cause that could produce this effect, except the fractured crust permitting water to penetrate to the heated interior of the earth, to generate steam sufficient in tension and quantity to effect the results observed; and we know not how the crust *could be fractured* except by contraction, and by collapse upon the contracted nucleus.

That some portions of the crust of the globe have been successively elevated and depressed, is beyond all doubt. Numerous instances have been observed during the historical epoch,* but the geological evidences of similar facts on a large scale, are as strong as if they had come under the direct observation of man.

That the elevation of one part was accompanied in times past by depression in others is probable theoretically, and we know that such facts have occurred paroxysmally during the historical era, as in the case of the Ullah Bund. Similar effects are now in progress secularly, as the coast of Sweden, which is gradually rising, and has been for a long period; the coast of Greenland,

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* A few examples may be adduced for illustration.

1st. An island in the Mississippi, and a large extent of the swamp near New Madrid, sunk during an earthquake in the year 1811. The Mississippi flows over the former site of the island, and the sunken portion of the swamp is now a lake.

2d. In the year 1819, a tract of land of about two thousand square miles near the mouth of the Indus at Sindrea sunk below the level of the sea, and an adjoining tract fifty miles long, called the Ullah Bund, was raised about ten feet above its former level.

3d. In the year 1692, the town of Port Royal in Jamaica sunk during an earthquake. The ships in the harbor floated from their anchorage and drifted over the site of the town, which remains permanently submerged. The part of the town where the quay was located sunk several hundred feet.

4th. In 1638, the town of Euphemia in Calabria sunk during an earthquake. A lake occupies its site.

5th. The coast of Chili in South America was elevated suddenly during an earthquake in 1822, over an extent of two hundred miles in length and forty or fifty miles in breadth into the interior. At one place some distance back from the which is stated to be gradually sinking ; a large area in the Pacific which is reported to be gradually sinking. The evidences of subsidence are not as easily obtained as those of elevation, because we must look for them beneath the level of the sea.

Still another cause of variation in the relative levels of land and sea may be adduced, though it may have had little real influence in the production of the effects observed. Any diminution in the volume of the earth resulting from secular refrigeration of the globe, would increase the velocity of rotation on its axis, and increase the centrifugal force in a higher ratio than the angular velocity. Any such increase would tend to draw off water from the polar regions to increase the oblateness of the spheroidal form of the earth necessary to give the form of equilibrium under these new conditions ; and if the crust of the earth be too rigid to yield to the same force, land that was before buried beneath the polar seas would emerge above their level ; and dry land would be submerged in the equatorial regions.

If on the other hand the solid materials forming the crust of the globe be *not* too rigid to yield to this force,* the effects of the centrifugal force cannot be allowed to have had so great an influence in the relative levels of land and water as would be due to the other case, in which the crust of the globe was supposed to be rigid and unyielding.

Another point bearing upon the elevation of land may be considered in this place.

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coast, the surface was raised forty or fifty feet, so that a stream was made to flow in an opposite direction.

6th. The repeated elevation and depression of the coast of the Mediterranean around the Temple of Serapis is considered as an established fact.

7th. In 1843, there was a sudden elevation of the coast of Sweden. It was called a sinking of the waters of the Baltic ; but as the adjoining coasts of Norway, Russia and Denmark, have not changed their water level with regard to the coast, and the waters of these coasts communicate freely, the fact cannot be explained except by the elevation of the land. During the year 1842, the waters of the Baltic were observed to be sinking, and on the 4th of May, 1843, a *sudden* change of level occurred, so that the steamer that was to have left the port of Travemunde on the 18th, was detained until the 21st. Shoals and rocks never before known, made their appearance on the S. W. coast of Sweden, near the Maelstrom, in 1843. (Am. Journal of Science, Vol. XLVII, p. 184–185.)

* It may be inferred that they are not too unyielding to be influenced by this force in consequence of the contortions, plications and foldings of the strata that have been observed on so many parts of the earth, which have been produced by other forces more powerful ; yet this may be supposed sufficient to bend the crust of the globe gradually.

It has been shown that the centrifugal forces vary inversely as the cubes of the radii. It is also well known that bodies of different densities are affected by the centrifugal force in proportion to their densities. As the solid materials of the globe are more dense than water, they would be more influenced by variations in the centrifugal force in proportion to their specific gravities; and as the centrifugal force is greatest under the equator, any diffused subterranean forces that may exist, and that tend to elevate portions of the earth's surface by their elastic tension, would be most effective under the equator, where gravity is less, and the centrifugal force greater than on any other portion of the earth's surface.

May not this cause have had some influence in producing the heights of mountains under the equator? It is well known that the highest are within or near the tropics, and that most of the highest in Africa and South America are almost under the equator.

Again, the influence of an increased velocity of rotation of the earth, would tend to make the polar regions flatten, and the equatorial regions become still more protuberant. Lines of fracture might be expected in the direction of small circles parallel to the equator, at a distance intermediate between the poles and the equator, where the curvature resulting from such a change of form would be the greatest.*

Ranges of mountains mostly of primary rocks, do, in fact, almost encircle the globe between 40° and 50° of north latitude, and in North America the strike is, in many parts, nearly E. and W. The great fractures seem to have been made nearly in this direction, even where the strike is different. The highest peaks of the Rocky Mountains, so far as is known, are in about 40° of north latitude; those of northeast New York and the White Mountains of New Hampshire about 44°; the ranges of the Pyrenees, the Alps, the Apennines, and the Carpathian Mountains in Europe are between 40° and 50°; the Caucasus Mountains, the Taurus Mountains, the Hindoo Koo Mountains, and the Ihian Chan Mountains in Asia, are among the most elevated on the globe and are found between 35° and 45° north latitude, and have a trend nearly E. and W.

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* Other fractures in the directions of meridians might be expected if the earth increased in its equatorial diameter.

In the southern hemisphere we do not find indications of such extensive upheaving action in the same parallels of latitude. The southern coast of New Holland, New Zealand, the Vulcan Mountains in South America, the Snow Mountains near the Cape of Good Hope, and a few islands lying between 30° and 50° south latitude, might be adduced as affording some degree of accordance with what has been noticed in the northern hemisphere.

Any considerable increase in the velocity of rotation of the globe on its axis, would first tend to bury the equatorial regions beneath the ocean, in consequence of the water obeying immediately the impulse of centrifugal force; while the crust of the globe, if not too rigid, would gradually yield to the influence of the same force until the form of equilibrium due to the new conditions should be restored. The flattening of the polar regions and the increased equatorial diameter would tend to make the strata press towards the equator and produce not only fractures at intermediate points as before alluded to, but also to elevate them along the lines of fracture above the level of the sea.

The elevation of islands, mountain chains, and continents, and subsidence of other parts beneath the level of the sea, seem to be the necessary and legitimate consequences of the secular refrigeration of the earth.

Profs. Rogers in April, 1840, stated to the Association of American Geologists, as one of the results of their labors in Pennsylvania and Virginia, that the mountain region of those states contained numerous examples of *folded stratification* in which the strata had been arched, and finally folded over in one direction. The under part of each fold had its strata reversed in relative position from that in which they were formed, and also reversed in superposition when compared with the upper part of the folded mass. This almost surpasses credibility, but it has been found to be very generally true in the most disturbed parts of the principal axis from Carolina to Vermont, and is now admitted, I believe, by all who have investigated the facts.

These folded and reversed strata all dip to the E. S. E. and S. E., usually at high angles. This fact of the strata dipping to the eastward, and apparently pitching under the primary rocks was long a stumbling block, and led to various mistakes in the relative ages of the sedimentary rocks. The broken up, crushed and folded strata, were supposed to be far older than the same rocks which were undisturbed.

Profs. Wm. B. and H. D. Rogers in their paper on the physical structure of the Apalachian chain of mountains* ascribe the elevation of that chain to an undulation of the fluid interior of the earth, combined with a lateral tangential force.

The whole range of mountainous country from Alabama through Tennessee, Virginia, Maryland, Pennsylvania, New Jersey, New York, and thence to Canada, has evidently been subject to an elevatory action, combined with a lateral or tangential force, that has elevated, broken, crushed, and plicated the strata, and in many places has folded them over, and reversed rocky strata of great thickness that were formerly horizontal rocks and formed beneath the ocean. Farther west, the plications and undulations become more and more gentle, until their angles of inclination become insensible to the eye.

On the east of the axis of principal disturbance, the primary and metamorphic rocks are also much broken and disturbed, and many of the sedimentary strata along the lines of disturbance have been much altered and modified in their aspect, structure, and mineral characters, by masses and veins of intrusive rocks.

Their explanation of the tangential force that has acted over so great an extent in the eastern parts of the United States is ingenious.† If it be true, the tangential force must have acted in every direction from that part of the earth's surface where the oscillations began, in the directions of the arcs of great circles radiating from an axis passing through the origin of the disturbance. The "*axis planes*" also of the folded strata, will be found to dip inwards towards the same axis; and the crests of the folded strata will all point outwards. These would be necessary results of an undulatory wave-like reciprocating motion flowing outwards from a centre, and a knowledge of this will aid in testing the truth of the theory of Profs. Rogers.

I will here offer another explanation of the folded strata dipping to the S. E., showing the possibility of another cause for a tangential force, in addition to that arising from collapse of the crust of the globe by refrigeration, and it seems to harmonize with the facts observed among the disturbed strata of the United States.

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* Transactions of the Association of American Geologists, 1840—1842, pp. 474—531.

† The Profs. Rogers refer the whole effects to oscillatory earthquake motion. Vide memoir, Trans. Assoc. Am. Geologists, 1840—1842, p. 517.

It has already been mentioned that these folded and disturbed strata extend from Canada on the N. through the Atlantic mountain region to Alabama on the S., a distance of at least one thousand miles. The cause of the disturbance has acted repeatedly along the same axis, producing the same effects, raising the solid massive strata of the globe into great undulations, crumpling, crushing, and pitching them over in some instances in mountain masses of folded strata, so as to give them all an eastwardly dip in the easternmost ranges. Where the strata are not folded, they are often broken by enormous longitudinal, transverse, and lateral faults.* These facts, together with contortions, crushed strata, the glazed and shivered slates, and the polished surfaces of fissures, lead to the conclusion that lateral motion has been produced by *some* cause. It may be conceded that a cause acting over so great an area may have been general, rather than local.

The phenomena of the earth being in the state of a cooling body, that cooling bodies diminish in volume, that bodies revolving on axes if diminished in volume and retaining the same quantity of matter increase in angular velocity, that the consequent increased centrifugal force would increase the oblateness of the spheriodal form of the earth, and the mobility of water would induce a flow of water from the polar to the equatorial regions to restore the form of equilibrium, have been considered in the preceding pages. The same cause of increased velocity of rotation would tend to produce similar results in the *solid* strata of the globe, if they be capable of yielding to such a force. That they *can* yield to such force is probable, from the fact, that the general form of the solid part of the globe, is the form of equilibrium of a body like the earth, revolving with its present velocity.

If the earth *has* at any time become more oblate in consequence of increased angular velocity, inertia would tend to make the solid matter of the exterior of the globe press to the westward, with a force dependent on its mass and its increased distance from the axis of rotation; and if there were lines at which motion could take place, slight motion might thus be expected to have been produced, and effects on the rocky strata, such as those mentioned, would be the necessary results.

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* Vide Geology of 1st Dist. New York, by W. W. Mather, and Rogers' Geological Report of New Jersey, and various geological papers.

If such motion has been produced, changes of longitude of masses of the earth's crust must have been effected, such as we trace evidences of in the wrinkled, crushed, crumpled, and folded strata, which, if laid out or developed in a mathematical sense, would occupy much wider areas than they do at the present time.

As the strata were elevated in wrinkles, the upper extremities being more remote from the axis of motion of the earth, the tops of the wrinkles would tend by the action of inertia to fall over to the westward,* and give a general eastwardly dip to all the strata that were highly elevated, such as we see to be almost constantly the case along that belt of mountainous country extending from Canada to Alabama.

If a motion to the westward be produced by the tangential force due to inertia, both from increased oblateness and from the elevation of folds, the effect would be a maximum at the equator, and be less and less as the latitudes increased. The effect would be to produce a strike to the E. of N. in the northern hemisphere and to the E. of S. in the southern hemisphere. Along the eartern part of the United States this conformity exists. The explanation above offered to account for the disturbed and folded strata with an E. S. E. and S. E. dip, a N. N. E. strike, and a lateral tangential force, seems plausible to the writer. It is based on the known laws of nature, it is sufficient to explain the phenomena in question, and as far as observations have been made in the United States it is believed to conform to facts.

The *causes* that may be supposed to have produced the elevation of islands and continents above the level of the sea, beneath which they were once buried; the inclination, contortion, wrinkling, folding and crushing of strata; the elevation of mountain chains in former times; the gradual changes of level with reference to the sea which have been and still are in progress on parts of the earth's surface, have been briefly considered; and notwithstanding the great variety of causes that have been assigned, such as volcanic action, undulatory motion of a fluid interior, the expansive force of elastic vapors, tangential forces by collapse upon a nucleus contracted by refrigeration, unequal contraction of land and water by refrigeration, and the effects of inertia and increased centrifugal force as influencing the ocean and the solid

* The reason for this is illustrated on pages 292, 293, *ante*.

strata of the globe, they may all, together with the phenomena of volcanic action, earthquakes, metamorphic action, the transport of the materials and the deposition of the sedimentary rocks, the great currents of the ocean, the distribution of fossiliferous organic life, the various derangements of the strata, and most of the phenomena of geology, be referred to the SECULAR REFRIGERATION OF THE EARTH, combined with the effects of *gravitation*, *inertia*, and the *rotation of the earth on its axis.*

The effects of these causes can be traced in imperishable characters in the solid strata of the globe through unknown ages of past duration, and the same causes may be expected to continue to act through all future time.

ART. VI.—*Description of the Solar Index, a new Magnetical Instrument;* by MARSHALL CONANT.

THE "Solar Index" is the name I give to an instrument which I have recently contrived, the object of which is when attached to the surveyor's compass to show at any place the variation of the *magnetic* from the *true* meridian; consequently enabling the surveyor or engineer with very little trouble to take his courses from the true north and south.

An instrument for this purpose, of simple construction, appears to have been for a long time a desideratum. And several forms at different times and by different individuals have been tried and abandoned, or obtained but very limited use. The simplicity of this, and the mode of using it, as well as the accuracy of the results it affords, seem to indicate a greater degree of utility; and induce me to send a description of the instrument, accompanied by its delineation, for publication in the American Journal of Science; adding that I do not design to restrict the manufacture and sale of it by means of a patent, but on the contrary wish it to be considered a free contribution to the arts.

The material of the instrument, except one or two pieces, is brass. A, is its base, which is fixed to the base of the compass by a single screw from underneath, having a milled head and of a size equal to those by which the sight vanes are usually attached to the compass. One edge of this base is concave, so as to fit the circular box of the compass on the outside. B, is a horizontal axis, turning in the uprights C and D. The end of this axis passing through D, has a screw cut upon it, and receives a nut F with two milled heads, which serves to fasten the axis in any position by bringing its shoulder firmly against the upright D. This nut, where it presses the upright D, should have a less diameter than this shoulder; that in being tightened it may not turn the axis. The other end of this axis is conical; and the upright C which receives it, presses hardly upon it, which prevents its becoming loose on wearing. These uprights are fastened to the base A, by screws underneath. E, is a tube screwing into one end of the horizontal axis B, and receiving the equatorial axis PQR, to which, on the part PQ, a small quadrant GHI is attached. This equatorial axis passes at right angles through the horizontal axis into the tube E, where it turns smoothly, admitting an equatorial motion to the bar K. The lower extremity of this tube is boxed with block tin, and the equatorial axis passes into it with a slight taper; thus affording the means of receiving the requisite degree of tightness to sustain the quadrant and its attaches in any position, while its own motion is sufficiently free. The cylindrical portion of this axis is about $\frac{1}{16}$ part of an inch longer than the tube will receive; that, on wearing, it may gradually sink into the tube and move there without play. A pivot soldered fast to the back of the bar K, in the common point of meeting of the medium line of this bar and that of the arm LM, passes through the centre of the quadrant and through the equatorial axis; where it turns freely, as the extremity of this arm moves along the limb H, and shows the various positions of the bar K, with respect to the equatorial axis. This pivot, which is slightly tapering towards the back of the instrument, has there a screw cut upon it, and receives a nut with a milled head, by which the requisite degree of tightness is obtained. This pivot is so large as to have the proper degree of tightness when the back of the bar K is about $\frac{1}{16}$ part of an inch distant from the face of the quadrant; and the arm LM, near its junction with the bar K, is slightly bent towards the face of the quadrant, so as to give a light pressure to the extremity of it upon the limb of the quadrant.

Attached to the arm LM, is a small spirit level; and it is furnished at its extremity with a vernier, by means of which it may be adjusted to any desirable position upon the limb H of the quadrant; and its position is secured by a screw at the back, like that of the common quadrant.

In the piece N is a convex lens, which brings the sun's rays to a focus upon the piece O, through which a hole is made of about $\frac{1}{16}$ of an inch diameter. The sun's focal diameter upon this piece being a little larger, causes a fine, bright ring of light to appear about the border of this hole, when the instrument is properly adjusted. The lens is fixed at a proper distance from the piece O, and this piece at a proper height above the edge of the bar K, by means of screws; the particular mode of doing which will be understood at once from fig. 2.

The quadrant, or more properly, the *septant*, is divided into degrees and halves, from 0 to 70°; 0 being upon the equatorial axis. At 35° is placed another 0, and 10 and 20 at the corresponding number of degrees distant upon each side of it. The purpose of this last series of numbers is, the greater convenience in making the adjustment for the sun's declination. The vernier is divided each way from the centre into 15 equal parts, which embrace an extent equal to 14 of the half degrees upon the limb of the quadrant; by this means the vernier is capable of measuring an arc of 2′ on the limb. When the central line of division or 0 of the vernier, is upon the 0 of declination, or at 35° from the 0 on the equatorial axis, the bar K is at right angles to this axis.

The quadrant is attached to the equatorial axis by three screws at the back, and the spirit level to the arm LM by two. The holes through this arm and the equatorial axis are about $\frac{1}{16}$ of an inch larger in diameter than the screws, and the heads of the screws set down square over them. I ought, however, to except that screw of the level nearest the bar K, the head of which is sunk, to allow a free motion over the radii GI. By this device it is easy to give the quadrant and level a proper adjustment.

The compass being placed firmly upon its tripod, with the base A fixed in its place and turned towards the south in a clear day, adjust the 0 on the vernier of the index to a distance upon the quadrant from 0 on the equatorial axis, equal to the latitude of the place, and put the equatorial axis into the tube E; level the compass either by means of the levels upon it, or in defect of them, as nearly as may be by the eye, and bring the plane of the quadrant into a position perpendicular to the horizon; loosen the screw F, and give to the tube a position which will bring the bubble of the spirit level on the arm LM into the middle of the opening, and fix it in this position by again tightening the screw F. Now give the compass a slow motion upon the tripod, and observe if this bubble maintain its position; if so, this adjustment is properly made; if not, repeat the latter part of the process; and in turning the compass, move the quadrant also a trifle upon the equatorial axis till the adjustment be well made. Fix now the 0 of the vernier to a distance from the 0 on the middle of the quadrant, equal to the declination of the sun at noon at the given place on the day of observation, *above* this 0, if the declination be north, but *below* it if it be south; turn the quadrant and compass so as to allow the sun's rays to pass through the lens and fall upon the piece O, when the sun is on the meridian; and adjust this piece in such a manner that the focal area of the sun shall overlap the area of the aperture in the piece, and form a fine, even ring about its edge. It will be well to test this adjustment on several days. When this has been done and the piece O firmly fastened by its screw, no further adjustments will be requisite except for different latitudes and declinations; and these can be easily effected by the surveyor or engineer in a very few minutes. The correct adjustments, indeed, of the base A, the quadrant, and level upon the arm LM, the tube with regard to the horizontal axis B, the lens, and the piece O, all belong to the manufacturer. How the piece O is adjusted I have already described. I will soon show in what manner the surveyor or engineer may make or test for himself these other adjustments. At present I will state how the instrument should be used for the purpose designated.

On any day when the sun shines, let the compass with the index attached be leveled, and the adjustments made for the latitude of the place, and the sun's declination for the hour; turn the compass with the index till the sun shines through the lens and forms a ring about the aperture in O; and the north and south points on the horizon of the compass will be in the true meridian, and the variation of the needle be seen at once. If observations at different times in the forenoon and afternoon give the same variations* at one and the same place, it is proof that all the adjustments have been well made.

In a survey of no great extent no new adjustments will be necessary for change of latitude; and if the *time* occupied in the

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* Or *nearly;* see first note following.

survey does not extend beyond two or three hours, no alteration of adjustment will in general be requisite for change of declination.

An hour or two about the middle of the forenoon and afternoon are the times most favorable to the greatest degree of accuracy in these observations. When the sun is near the horizon, the refraction of his rays may produce an error of several minutes in the result; and when he is near the meridian, a small error in any of the adjustments is the more likely to affect the accuracy of the result; but less in both these cases than can be estimated by compasses in general use.

It would be very convenient to have a level placed upon the base A, underneath and parallel with the horizontal axis B; though it can be dispensed with.

A compass with a horizon accurately graduated and furnished with a vernier capable of measuring an arc of one or two minutes, will, with this index attached, afford the means of making very accurate surveys. Let all parts of the support of the compass be strong and well made; and let not any little difficulties which always attend the first trials of a new instrument, create doubts as to its complete success. For a very little practice will show the exceeding simplicity of its structure, and the facility and accuracy with which it operates.

And I wish here to impress upon surveyors and engineers the importance of noting all their courses from the *true meridian;* and of adding, in all their reports of surveys, the *variation* of the needle. I know this is already the practice of certain individuals among them; but were the practice general it would put an end to a multitude of mistakes, and arrest in some portions of our country a large amount of litigation, which has arisen from the difficulty of finding the fluctuations of variation in individual surveys. These fluctuations are mainly owing* to the proximity of iron ores, and occur much more frequently in surveys than I formerly apprehended.†

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* I say *mainly;* the influence of the sun upon the needle causes its declination from the meridian to be greater by 13′ to 15′ at 3 o'clock P. M. than at 8 o'clock A. M., in the summer; and 8′ to 10′ greater in winter.

† And I have no doubt that cases like the following, reported by Capt. Scoresby, are frequent at sea, and if not guarded against produce serious disasters. In sailing down the British Channel, he observed the variation of the needle to be 2° or 3° greater than in sailing up it in the same ship, which he attributed to the improper *lading* of the ship.

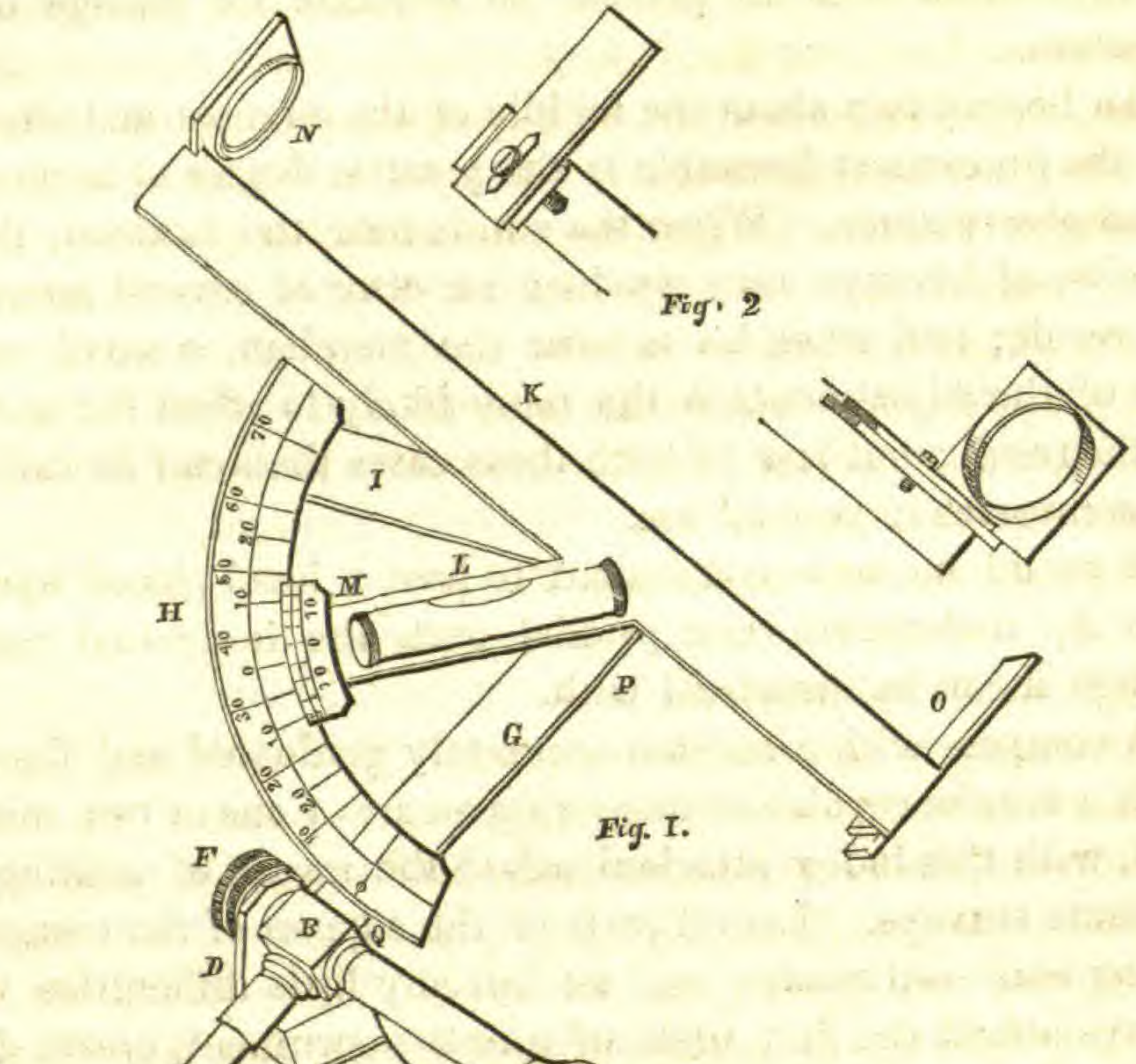
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Fig. 2
K
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Fig. I.
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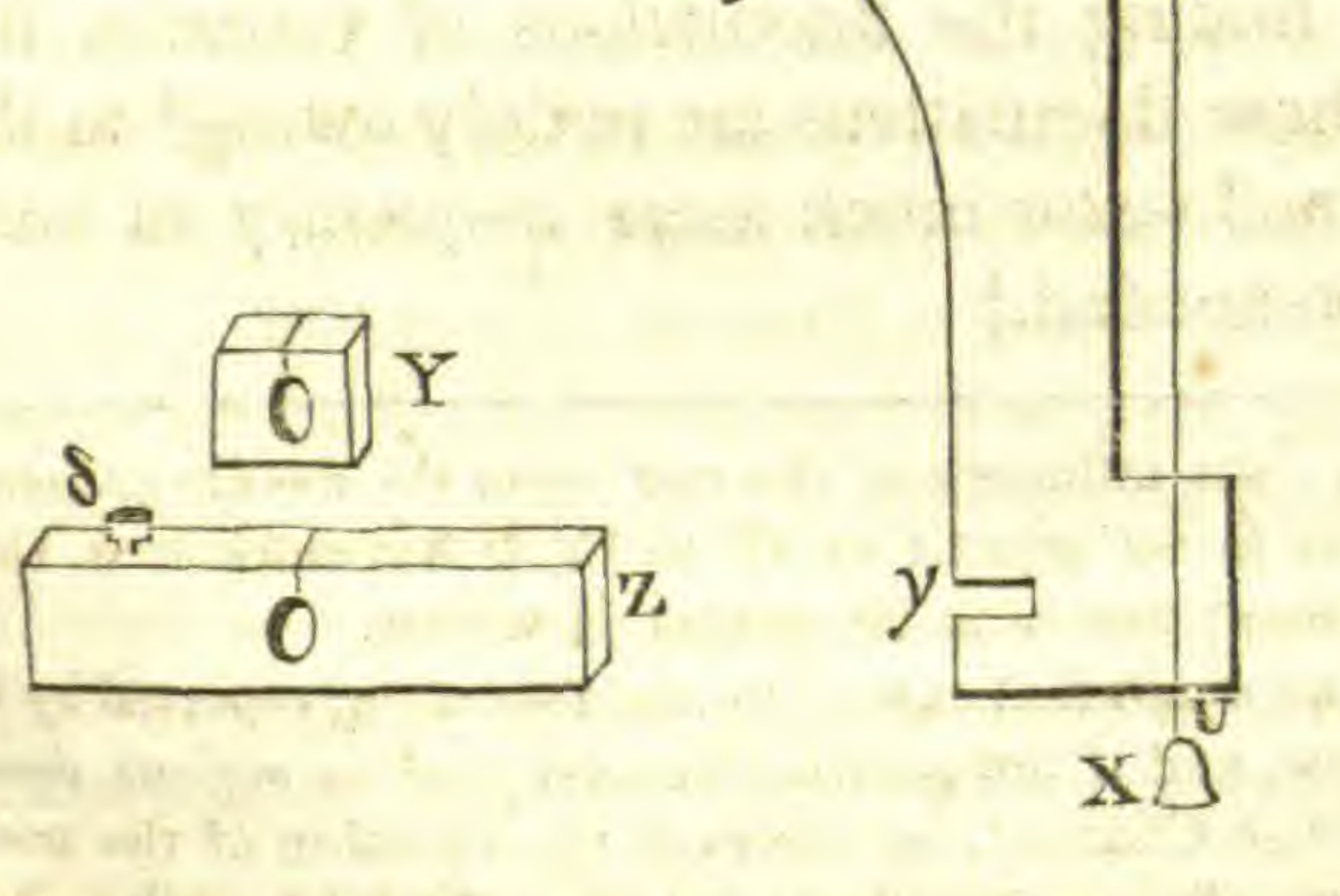
R
A


T
W
V
S
Fig3
Y
δ
Z
y
U
X

Size of the several parts of the Instrument.

Length of the horizontal axis B, . . .	$3\frac{1}{2}$	inches.
Diameter of the square part of this axis, . .	$\frac{6}{10}$	"
Height of this axis above the base A, . .	$1\frac{9}{20}$	"
Length of the tube E, including the diameter of the axis, ...	$3\frac{6}{10}$	"
Width of the uprights C and D, ...	$\frac{9}{10}$	"
Thickness of these and of the base A, . .	$\frac{7}{40}$	"
Radius of the quadrant, (to the middle of the limb,)	$3\frac{7}{40}$	"
Breadth of the limb, ...	$\frac{1}{2}$	"
Breadth of the radii G and I at the limb, . .	$\frac{1}{2}$	"
" " " at the centre, .	$\frac{6}{10}$	"
Thickness of the quadrant, ...	$\frac{3}{40}$	"
Focal length of the lens, ...	7	"
Diameter of the lens, ...	1	"
Distance of the lens from the centre of the quadrant,	$4\frac{1}{2}$	"
Width of the bar K, ...	$\frac{7}{10}$	"
Diameter of its pivot, ...	$\frac{7}{30}$	"
The arm LM of the same width with the bar K, where it branches from it; but narrows a little toward the vernier.		
The vernier in my instrument is of silver, and soldered firmly upon the extremity of the arm LM, which is shaped so as to receive it.		
Thickness of the bar K and of the arm LM, a trifle less than	$\frac{1}{10}$	"
Length of the spirit level upon the arm, . .	$2\frac{1}{4}$	"
Diameter of the cylindrical portion of the equatorial axis at Q, ...	$\frac{7}{20}$	"
Diameter of do. at R, ...	$\frac{5}{20}$	"

That portion of this axis which receives the quadrant is $\frac{1}{2}$ an inch wide at the centre of the quadrant, and $\frac{9}{20}$ of an inch at Q. It is first made $\frac{7}{20}$ of an inch thick, and receives the quadrant imbedded into one side of it about $\frac{1}{10}$ of an inch; it is then filed off on the opposite side till it is left about $\frac{2}{10}$ of an inch thick.

These dimensions afford an instrument of very proper and convenient size; which will be found of easy construction, and little liable to get out of order. It can be snugly packed in a box about half the size required for the compass,—the equatorial axis and its appendages in one department, the base and parts connected with it in another. When applied to other instruments than the compass, this index may be made of any size thought proper; but I would advise to have the same relative proportion of parts maintained.

Of the Adjustments.

Fig. 3 is an adjuster; which is simply a piece of smooth sheet copper or brass, 8 inches long and 4 wide at the top.* Over the centre of the hole S, are drawn the very fine lines TU, VW, at right angles. X, is a small weight or plumb, suspended by a fine black hair fastened in a cut in the lower edge of the hole S. At the foot of the line TU, is another cut.

X being suspended by its hair on the side of the plate shown in the figure, let the bar K with its appendages be taken from the quadrant, and placing its pivot in the hole S, made just large enough to receive it, move the arm LM till the 0 on the vernier shall be on the line VW, and here make it fast by the screw at the back; then fix the whole in such a position that the hair shall hang freely by the side of the plate and directly over the line TU; adjust the level upon the arm LM, so that the air bubble shall rest truly in the middle of the opening, and fix it permanently in this position by means of its screws.

Y and Z, are pieces of block tin or brass, $\frac{1}{4}$ of an inch thick, fitting on to the equatorial axis; the piece Y near the quadrant, and Z near the extremity R. A fine line is drawn upon the edges of these pieces over the central section of the holes.

Let these pieces be placed upon the equatorial axis, with their marked edges in a plane with the face of the quadrant; take the plate fig. 3 and fix the hair in the cuts at S and U, on the side of the plate as seen in the figure, and placing the hole S to the centre of the quadrant, put the pivot of the bar K in its place with the arm LM opposite the quadrant, and bring the slit γ under the screw head δ and make the hair truly parallel with the lines upon the pieces Y and Z, and secure this position by tightening the screw; then adjust the quadrant so that the 0 of the equatorial axis shall appear exactly under this hair, and make it fast in this position. A good eye will enable one to get this parallelism

* But drawn here, for the sake of convenience, of a size relatively too small.

and make this adjustment very accurately. During the process it will be important to keep the hair well stretched.

The manufacturer should take care to have the plane of the face of the quadrant parallel to the central line of the cylindrical portion of the equatorial axis. If the central line of the pivot should not meet with the central line of the cylindrical portion of this axis, the preceding adjustment will remove *that* source of error.

The central line of the horizontal axis B should be parallel with the base A of the instrument; and a fine line should be drawn upon the top of each of the uprights C and D, in direction of the axis and directly over its central section. Also a fine line should be drawn at right angles to the face B, over the centre of the hole near Q, which receives the equatorial axis; as likewise across the hole at the extremity R of the tube. By means of these it will be easy to know if the tube is at right angles to the axis, and if not to bring it into this position.

Let the base A be put upon the base of the compass on the side of the box opposite the spirit levels, or, if the compass has a vernier on the side opposite the levels, remove the levels and place the base there, confining it by its appropriate screw. Removing the glass from the compass, fix it at a convenient height with the plane of its horizon perpendicular with the horizon of the place, so that facing it and suspending the plumb X by its hair directly in front of it and as little distant as practicable, the hair when still shall appear at one view to pass over the east and west points of division; then if the plumb be brought before the ends of the uprights C and D, and the hair appear at one view to pass exactly over the fine lines drawn upon them, the base A will be in its right position. But if both of these do not disappear at one view behind the hair, alter the position of A, and proceed as before, till the right adjustment of the base shall be effected; the horizontal axis B will then be parallel with the line joining the east and west points on the horizon of the compass. Let a mark be made on the base of the compass corresponding with one made on the edge of A. By means of these alone the base A can ever after be placed and fixed in its proper position; and there will be no further occasion for removing the glass to accomplish it.

Framingham, Mass., July 12, 1845.

Art. VII.—*A Report to the Navy Department of the United States on American Coals, applicable to Steam Navigation and to other purposes;* by Prof. Walter R. Johnson.

The area of the various coal basins embraced within the territory of the United States, is probably greater than that of any other of the civilized nations of the earth. Since the application of steam as a motive power, this mineral fuel has become an important element of national prosperity, and within a few years has assumed a prominent position among the materials of national defence. As might be expected in so vast an extent of territory, a corresponding diversity of character exists in the coals of the United States. From the plumbaginous anthracites of Rhode Island and Massachusetts they shade off to the highest bituminous character. Common observation indicated a corresponding difference in applicability, and to some extent in the calorific powers of the coal in these various conditions. Chemical analysis had in some instances shown their elementary differences. But no systematic and authoritative examination, of a kind from which general *practical* inferences might be deduced, had been performed up to the time at which the investigations embraced in this Report were commenced. Such examinations, highly important to individual interests, were absolutely necessary in a national point of view. The steam vessels of the Navy are exposed to the performance of various duties, in the course of which it is often necessary to replenish their exhausted fuel at different stations. The best informed engineer would be often embarrassed in his operations by the difference in the character of the coals he would find at these stations, and thus endanger the success of the best concerted cruise or system of operations. This is peculiarly liable to occur in the coast service of the United States. Along the northern and eastern Atlantic coast the anthracites are most used, while in the Gulf of Mexico the bituminous coals of the Mississippi valley must be depended upon. A long life of practical operations would not give the engineer the same facility of adapting his engines to these differences, as he would be enabled to obtain by the study for a few weeks of such experiments as those detailed in this Report.

It is greatly to be regretted that this examination did not embrace all the coals, or rather all the varieties of coals, with which our country abounds ; and also those which our steam-ships will be obliged to use whilst cruising on distant stations. But no blame for this defect can attach to the Department under whose direction these experiments were made. It availed itself of all the means that seemed justifiable to secure so desirable an object. Advertisements were kept standing for months in the most prominent papers of every part of the Union, inviting mine owners and others to forward samples for investigation to the Navy Yard at Washington, where the whole operation would be conducted free of expense to those furnishing the samples; whilst a sufficient supply of the foreign varieties found in our markets was purchased for comparative trials under the direction of the Department by Prof. Johnson. The most important deficiency that can be found in this respect is in the coals from the Mississippi valley. From the great Illinois and Missouri coal basin, covering an area probably larger than the whole kingdom of France or Great Britain, a single sample was forwarded, whilst from that portion of the extensive basin of Pennsylvania, Virginia and Ohio that lies west of the Alleghany Mountains, an amount still less than from the former was obtained. Neither of these was in quantity sufficient to make a full series of experiments. We speak knowingly when we state, that the sample from the Illinois and Missouri basin (Cannelton, Ind.) was not a fair representation of the largest part of the coals furnished by these basins. This deficiency is much to be regretted ; and if the results of the examination of the other coals embraced in this Report, be as important to the national interests as we believe they are, it calls loudly for a continuance of these experiments in such a manner as to insure an investigation of these western coals.

What was *done*, was done *thoroughly*. The period occupied in the experiments and working up the results was about eighteen or twenty months. The Report covers more than 600 pages of congressional documentary form, most of which is tabulated matter. The number of samples of coal experimented upon was forty one, viz. nine anthracite, twelve *free burning* or *semi*-bituminous, and nineteen bituminous,—to which may be added one sample of *natural coke*, two of artificial coke, two mixtures of anthracite and bituminous coals, and one of dry pine wood. Two of the anthracites were from the Beaver Meadow mines, sent by the Beaver Meadow Railroad and Coal Company; two from the same mines, procured by the Navy Department for the use of the Navy; one from the Lehigh Coal and Navigation Company's mines, sent by the Company; one from "Lackawana," sent by the Delaware and Hudson Canal Company; one from "Peach Mountain," Schuylkill county, sent by the Delaware Coal Company of Philadelphia; one from Forest Improvement mines, Broad Mountain, Schuylkill county; and one from Lyken's Valley Coal Company, Dauphin county,—all being from mines within the state of Pennsylvania. Of the semi-bituminous or *free burning* class, six were from the coal field in the neighborhood of Cumberland, Maryland; viz. one from Atkinson's and Templeman's mine; one from Neff's mines; two from Easby's mine, called coal in stone; one from the New York and Maryland Mining Company; and one from a quantity of "Cumberland coal," purchased for the use of the Navy. The first five were furnished by the proprietors of the mines. The six other semi-bituminous coals were from Pennsylvania, consisting of one from Karthaus, on the west branch of the Susquehanna; one from Cambria county, sent by J. Brotherline; one from Lycoming Creek, sent by A. McIntyre, near Ralston, Lycoming county; one from Blossburg, Tioga county, sent by the Arbon Coal Company; one from Quin's Run, Clinton county, sent by McDonald & Hollenback; and one from Dauphin and Susquehanna Coal Company, sent by Isaac Lea, Esq., of Philadelphia. Of the bituminous coals, eleven were from the coal fields in the vicinity of Richmond and Petersburg in Virginia, viz. five from the Midlothian mines, furnished by the Midlothian Coal Company; one from the Deep Run mines of J. Barr, Esq.; one from the Tippecanoe mines, P. D. & F. D. Osborne & Co., agents; one from the Clover Hill Company; one from the Chesterfield Mining Company, and one from the mines of Crouch & Snead.

It will be observed that the whole of these coals were from the eastern slope of the Alleghanies. Besides these there were two other samples of bituminous coal from the Mississippi valley; one from Cannelton, Indiana, from the American Cannel Coal Company, sent by James Boyd, Esq., and one from Pittsburg, Penn., sent by W. T. Hepp & Co., of New Orleans.

To the list of American coals should be added one sample of "*natural coke,*" from Tuckahoe, Virginia, sent by Messrs. Barr & Deaton; one sample of artificial coke, made from the Midlothian coal that had been procured for the use of the Navy, and another sample made from Neff's (Cumberland, Md.) coal,—besides which, as before remarked, the efficacy of mixtures was tested by a series of experiments; one mixture of one-fifth Midlothian and four-fifths Beaver Meadow, and another of one-fifth Cumberland (Md.) and four-fifths Beaver Meadow.

The remaining six bituminous coals examined were foreign. Two of these were sent by Mr. Cunard, agent of the General Mining Association of London,—one of which was from Sidney, the other from Pictou, Nova Scotia. The other four samples of foreign coal consisted of one Scotch, one Newcastle, one Liverpool and one Pictou, and were purchased by the order of the Department of Messrs. Laing & Randolph, extensive dealers in coal at New York.

It will thus be seen that the various coals were obtained from those who could be depended upon as furnishing truly the article represented. There appears to be no reason to doubt that the samples furnished were fair specimens of the various kinds of coal found in the market.

The experiments for the evolution of practical results were performed in the Navy Yard at Washington City. The apparatus consisted of a double flue cylindrical boiler, thirty feet long and three and a half feet in diameter,—the flues being ten inches in diameter. A cistern whose cubic contents were carefully measured, was placed above the boiler to maintain a proper supply of water, and by which the quantity of water evaporated during each experiment was determined. The boiler was furnished with two safety valves of the simplest form, with the weights acting directly upon them. These served to regulate the pressure of the steam generally, but it was measured by a manometer or mercurial gauge, carefully graduated, communicating with the steam in the boiler, but under such circumstances as to be free from the influence of its temperature. The size of the grate and the area of the heating surfaces were all completely measured. The draft was determined by a syphon draft-gauge and other means. A register of the barometric, thermometric, and hygrometric condition of the atmosphere was constantly kept. A thermometer was so disposed as to determine the temperature of the air as it entered the grate, after having been made, by the construction of the stack, to pass entirely around the two sides of the boiler and under the ash-pit and main fire-place. Other thermometers were so placed as to determine the temperature of the air and gases as they escaped into the chimney after combustion, that of the water in the supplying cistern, and that of the steam and water in the boiler. The coals were measured and weighed in charges, that is, in a box containing exactly two cubic feet. Care was taken to reduce them all to the size best adapted to their combustion. They were charged regularly, so as to keep them as nearly as possible in a uniform state on the grate. During the experiment a portion of each coal was carefully dried by means of an apparatus prepared for this purpose, to determine the amount of hygrometric moisture. The rate and manner of combustion were carefully observed, and the ashes, clinker, &c. weighed and preserved for subsequent analysis. By an arrangement exhibited in Plate II of the Report, a portion of the gases, atmospheric air, &c. of the chimney, after passing through the ignited fuel, was collected and analyzed. The soot deposited on the sides of the flues and other passages was also collected, weighed, and submitted to the same chemical investigation.

The air intended for the support of combustion entered an opening below the ash-pit, and passing thence through air chambers on each side of the boiler, so as to absorb the heat radiated from this body, entered the fire by a passage from the back of the stack, directly under the flue below the boiler. After traversing the fire, the gases and other products of combustion passed under the whole length of the boiler, returned through it by the two interior flues before mentioned, and communicated with one of the flues leading directly to the chimney. This however was susceptible of being closed by a damper, in which case the gases, &c. passed by another series of flues entirely around and outside of the boiler below the level of the water line, and then escaped into the chimney. By this latter arrangement, so perfect was the absorption of the heat generated by the fuel, that the gases on entering the chimney were rarely more than 60° or 70° hotter than the steam in the boiler, and often much less.

One trial or set of observations generally occupied about twenty four hours. It was commenced by heating the water in the boiler to a certain temperature (usually 230°) by means of a weighed quantity of dry pine wood. During this period no steam was allowed to escape. The coal was then substituted, after withdrawing and weighing the unburnt wood, and the process continued with coal alone to the end. The ashes which the required quantity of wood would give having been determined by other experiments, were deducted from the whole amount of residue left.

The following table, extracted from the Report, will give some idea of the observations at each trial, their variety, and the care with which they were made. (See table on succeeding pages 316, 317.)

The weight of coal consumed at each trial was generally from 800 to 1200 pounds. Four trials were generally made upon each sample of coal. The mode of conducting the combustion was in some respects varied in the different trials, chiefly with a view of determining the influence of such changes or modifications upon the efficiency of the material. One important modification in operation, which was introduced in the experiments upon almost every species of coal, and to which we have not yet referred, was the introduction of fresh atmospheric air to the gases immediately behind the grate. This was accomplished by placing in that part of the apparatus a perforated iron plate, through which the air from the ash-pit below could pass, and which could be closed by simply drawing over it another perforated iron plate. The effect of this modification in the manner of conducting the combustion is shown in the course of the experiments.

The tables of daily trials made upon each coal are followed by another, in which all the most important facts, either of observation or deduction, are clearly tabulated. No explanation in relation to this table, within the limits we have assigned for this review, would be so satisfactory an exhibition of its character as the table itself; we therefore submit one selected at hazard. Some things in this table may possibly not be fully comprehended by mere inspection, but the limits of this review do not allow us to enter into an explanation of them. The Report itself does this fully upon every point, and we therefore must refer the reader to that document for such farther information as may be necessary. (See the table inserted on pages 318, 319.)

FOREST IMPROVE-

Third trial—upper damper 4 inches open; air

Date.	Hour.	Temperatures of the: Open air entering below ash-pit.	Wet bulb thermometer.	Air entering back of grate.	Gas entering chimney.	Water in tank.	Steam in boiler.	Attached thermometer.	Height of barometer.	Height of manometer.	Volumes of air in manometer.	Height of water in syphon.	Weight of water in tank.	Weight of charges of coal.
	h. m. A. M.													
Aug. 7	4 45	80	76	150	170	80	184	80	30·11	0·349	7·06	0·13	–	–
	6 07	81·5	77	154	248	80	225	79	30·09	0·527	5·30	0·20	–	104·00
	6 37	81	77	158	226	80	229	80	30·10	0·552	5·05	0·18	–	107·00
	7 00	81	77	157	230	80	232	81	30·10	0·564	4·94	0·17	–	–
	7 30	82	77	160	222	78	226	82	30·10	0·503	5·54	0·20	164	–
	8 00	82·5	77·5	160	210	78	226	82	30·10	0·512	5·45	0·20	–	–
	....	...	...	...	...	...	...	...	....	....	...			
	8 30	84	78	162	222	78	227	83	30·10	0·521	5·36	0·21	–	104·25
	9 00	84	78	165	244	78	227	84	30·11	0·523	5·34	0·21	309	–
	9 30	85	78	167	256	78	229	85	30·11	0·529	5·28	0·23	401	–
	10 00	87	79	169	218	78	228	85	30·11	0·525	5·32	0·25	739	–
	10 30	88	79	189	250	78	229	85	30·11	0·535	5·22	0·34	991	100·25
												...	...	.....
	11 00	90	80	186	254	79	229	86	30·11	0·524	5·33	0·22	1249	–
	11 30	90	80	198	260	79	230	87	30·11	0·535	5·22	0·23	1419	–
	P. M.													
	0 00	91	80·5	208	252	79	230	87	30·10	0·527	5·30	0·19	1674	104·75
	0 30	94	80	224	248	79	228	88	30·10	0·521	5·36	0·18	2054	–
	1 00	88	78	225	–	79	231	88	30·10	0·542	5·15	0·20	2259	–
	1 30	91·5	79	235	246	79	230	87	30·07	0·530	5·27	0·16	2592	111·00
	2 00	94	80	249	248	80	230	88	30·08	0·537	5·20	0·19	3014	–
	2 30	95	80	253	244	79	230	88	30·08	0·523	5·34	0·18	3334	–
	3 00	93	81	264	238	80	229	89	30·06	0·523	5·34	0·18	3589	118·75
	3 30	92	81	275	250	81	230	89	30·06	0·530	5·27	0·18	3839	–
	4 00	94	81	288	255	81	230	89	30·06	0·535	5·22	0·18	4215	–
	4 30	92	81	296	250	84	230	89	30·05	0·525	5·32	0·18	4530	115·00
	5 00	92	80	316	248	84	230	88	30·05	0·523	5·34	0·17	4783	–
	5 30	90	79	320	259	84	230	87	30·05	0·527	5·30	0·18	5027	101·50
	....	...	...	...	...	...	...	...	....	....	...	...	...	.....
	6 00	96	92	343	249	84	230	87	30·05	0·550	5·07	0·17	5445	–
	6 30	92	82	382	228	84	229	86	30·05	0·533	5·24	0·18	5973	–
	A. M.													
Aug. 8	5 20	80	77	236	214	84	225	81	30·05	0·497	5·58	0·14	5980	–
	6 05	82	77	214	206	84	211	81	30·06	0·348	7·07	0·15	7567	–

Period of steady action from 10*h.* 10*m.* A. M. to 5*h.* 30*m.* P. M. = 7*h.* 20*m.*, embracing 14 sets of observations; coal supplied to grate, 551 lbs.; water to boiler, 4,204 lbs.; water to 1 of coal, during said period, 7·629.

MENT ANTHRACITE.

plates closed; steam thrown out at back valve.

Time each charge was on grate.	Dew point, by calculation.	Gain of temperature by the air before reaching the grate.	Difference of temperature between steam and escaping gases.	Water per square foot of absorbing surface per hour.	REMARKS.—Grate surface 14·07 square feet; length of circuit of heated air 121 feet; height of chimney 63 feet.
h. m.					
–	74.6	70	—14	–	Water 0·12 inch below normal level; commenced firing; fire in small furnace; two weights on safety valves; commenced charging with coal at *6h. 7m.*; consumed 183¾ lbs. of wood; water in boiler, 0·47 inch above normal level; temperature 225°; fire kindles slowly; took at *7h. 0m.* the second weights from valves; syphon rose to 0·30; steam began to blow off; at *7h. 30m.* filled tank.
6·07	74·9	72·5	+23		
6·37	75·6	77	— 3		
–	75·6	76	— 2		
–	75·3	78	— 4	0·821	
–	75·8	77·5	—16	–	A charge of this coal reduced to egg size, weighs 105 lbs.
	...	...			
8·30	76·1	78	— 5	–	Kindling takes place slowly.
–	76·1	81	+17	0·554	Wind S., light; hazy, sun shining occasionally.
–	75·8	82	27	0·434	Set upper damper to 4 inches at *9h. 35m.*; coal igniting more freely.
–	76·6	82	20	1·791	
10·10	76·3	101	21	1·335	
...			...	...	
–	77·2	96	25	1·367	
–	77·2	108	30	0·636	Fire in small furnace extinct, and its damper closed; dew point, by observation, 74°.
0·00	77·6	117	22	1·351	Steam all thrown out at back valve.
–	76·1	130	20	2·013	Commenced drawing gases from lower opening at *0h. 42m.*; drew in 25 minutes 80 cubic inches, which gave 0·68 grain water, 4·33 grains carbonic acid, and 8·018 cubic inches of oxygen; temperature at bath 87°; at *0h. 30m.* P. M. wind N. W.; showery.
–	74·9	137	–	1·086	
1·30	75·3	143·5	16	1·764	
–	76·1	155	18	2·236	
–	75·9	158	14	1·695	
3·00	77·8	171	9	1·351	Wind N. E., light; clear.
–	78·0	183	20	1·324	Wind S.; dew point, by observation, 76°; by calculation, at same place, 77°·3.
–	77·5	194	25	1·992	Eighth charge shows much earthy matter in partings, technically called "bony coal."
4·15	78·0	204	20	1·669	Filled tank at *4h. 15m.* P. M.
–	76·6	224	18	1·340	Cloudy; wind E., light.
5·30	75·8	230	29	1·293	
...	...	...	...	...	
–	78·4	247	19	2·215	Contents of ash-pit thrown on grate; both valves double weighted.
–	79·4	290	— 1	–	Water in boiler left at 1·6 inch above normal level.
–	76·0	156	—11	–	Water found 3·10 inches below normal level.
–	75·3	132	— 5	–	Water in boiler adjusted.

RESIDUA.

	Pounds.
Clinker,	4·00
Ashes,	71·25
Ashes behind bridge,	1·26
Total,	76·51
Deduct wood ashes,	0·564
Total waste from coal,	75·946
Coke,	67·99

Deductions from Experiments on Easby and Smith's coal, (Cumberland.)

	Nature of the data furnished by the respective trials.	1st Trial.	2d Trial.	3d Trial.	4th Trial.	5th Trial.	Averages.	Remarks.
		Oct. 4.	*Oct.* 5.	*Oct.* 6.	*Oct.* 7.	*Nov.* 16.		
1	Total duration of the experiment, in hours, - - -	24·583	23·167	22·383	27·333	10·667		
2	Duration of steady action, in hours, - - - - -	6·9	7·433	7·683	4·517	2·667		
3	Area of grate, in square feet, - - - - - - -	14·07	14·07	10·291	14·07	14·07	- -	It will be remarked that the size of the grate in the 3d trial was much less than in either of the others—reduced by rows of bricks on the sides. No advantage appears to have attended this alteration, as will be seen by consulting the deductions below, lines 40, 41, 42, and 43.
4	Area of heated surface of boiler, in square feet, - -	377·5	377·5	377·5	377·5	377·5		
5	Area of boiler exposed to direct radiation, in square feet,	18·75	18·75	18·75	18·75	18·75		
6	Number of charges of coal supplied to grate, - - -	11·0	11·0	8·0	8·0	6·0		
7	Total weight of coal supplied to grate, in pounds, - -	1105·0	1120·5	818·75	833·75	624·25		
8	Pounds of coal actually consumed, - - - - - -	1102·0	1115·0	807·0	829·0	622·5		
9	Pounds of coal withdrawn and separated after trial, -	3·0	5·5	11·75	4·75	1·75	5·35	
10	Mean weight, in pounds, of one cubic foot of coal, - -	50·227	50·931	51·1718	52·109	52·0208	51·2919	
11	Pounds of coal supplied per hour, during steady action, -	116·993	108·603	79·135	113·134	117·592	107·092	
12	Pounds of coal per square foot of grate surface, per hour,	8·314	7·718	7·689	8·041	8·351	8·0226	
13	Total waste, ashes and clinker, from 100 pounds of coal,	9·695	9·982	10·137	9·6605	8·9575	9·6864	
14	Pounds of clinker alone, from 100 pounds of coal, - -	3·8286	3·4422	2·6543	2·9928	2·3097	3·0455	
15	Ratio of clinker to the total waste, per cent. - - -	39·492	34·485	26·183	30 979	25·7855	31·3849	
16	Total pounds of water supplied to the boiler, - - -	9738·0	9971·0	7001·0	7587·0	5320·0		
17	Mean temperature of water, in degrees Fahrenheit, -	62°·5	63°·2	67°·0	67°·6	46°·0		
18	Pounds of water supplied at the end of experiment, to restore level, - - - - - - - - - -	188·0	669·0	567·0	2780·0	0·0	- -	The 5th experiment was brought entirely to a close and the water level adjusted, before leaving the apparatus, on the day of trial.
19	Deduction for temperature of water supplied at end of experiment, in pounds, - - - - - - - -	27·0	100·0	78·0	363·0	0·0		
20	Pounds of water evaporated per hour, during steady action,	1071·18	954·39	678·02	924·11	1051·544	935·849	
21	Cubic feet of water per hour, during steady action, - -	17·183	15·27	10·848	14·785	16·825	14·973	
22	Pounds of water per square foot of heated surface per hour, by one calculation, - - - - - - -	2·837	2·528	1·796	2·448	2·786	2·479	
23	Pounds of water per square foot, by a mean of several observations, - - - - - - - - - - -	2·821	2·509	1·788	2·467	2·725		
24	Water evaporated by 1 of coal, from initial temp. (a) final result, - - - - - - - - - - - -	8·803	8·8529	8·5785	8·7141	8·546	8·6989	

25	Water evaporated by 1 of coal, from initial temp. (b) during steady action, - - - - - - -	9·156	8·788	8·567	8·5	8·911	8·7844	
26	Pounds of fuel evaporating one cubic foot of water, - -	7·0998	7·0598	7·2856	7·1724	7·3134	7·1862	
27	Mean temperature of air entering below ash-pit, during steady pressure, - - - - - - - - -	69°·03	72°·3	73°·44	77°·93	60°·4		
28	Mean temp. of wet bulb thermom., during steady pressure,	57°·5	60°·8	64°·42	71°·5	56°·7		
29	Mean temperature of air, on arriving at the grate, - -	231°·61	221°·5	198°·94	220°·64	170°·7	208°·68	
30	Mean temperature of gases, when arriving at the chimney,	291°·39	310°·1	304°·11	308°·29	282°·9	299°·36	
31	Mean temperature of steam in the boiler, - - - -	233°·61	232°·9	230°·72	232°·71	232°·4		
32	Mean temperature of attached thermometer, - - - -	65°·56	67°·2	70°·0	72°·86	56°·8		
33	Mean height of barometer, in inches, - - - - -	29·924	30·1375	29·98	29·704	30·132		
34	Mean number of volumes of air in manometer, - -	4·846	5·0435	5·1311	5·185	4·987		
35	Mean height of mercury in manometer, in atmospheres,	0·5727	0·5525	0·5441	0·5383	0·5579		
36	Mean height of water in syphon draught-gauge, in inches,	0·3866	0·3825	0·3529	0·3664	0·35	0·3677	
37	Mean temperature of dew point, by calculation, - -	48°·5	53°·3	59°·26	68°·69	53°·54		
38	Mean gain of temperature by the air, before reaching grate,	162°·58	149°·2	125°·5	142°·71	110°·3	138°·06	
39	Mean difference between steam and escaping gases, -	61°·47	85°·5	75°·19	78°·46	59°·5	72°·02	
40	Water to 1 of coal, corrected for temperature of water in cistern, - - - - - - - - - -	8·803	8·8529	8·5631	8·6971	8·546	8·6924	
41	Water to 1 of coal, from 212°, corrected for temperature of water in cistern, - - - - - - - -	10·085	10·1336	9·7686	9·9164	9·9233	9·9654	
42	Pounds of water, from 212°, to one cubic foot of coal,	506·54	516·11	499·88	516·73	516·22	511·096	
43	Water, from 212°, to one pound of combustible matter of the fuel, - - - - - - - - - - -	11·1676	11·2573	10·8705	10·977	10·8997	11·0344	The open air-plate appears to have produced some advantage in the 2d trial of this sample.
44	Mean pressure, in atmosphere, above a vacuum, - -	1·4958	1·4425	1·4328	1·4123	1·441	1·4449	
45	Mean pressure, in pounds per sq. inch, above atmosphere,	7·3222	6·5352	6·3917	6·089	6·5126	6·5701	
46	Condition of the air plates at the furnace bridge, - -	Closed.	Open.	Closed.	Closed.	Closed.		
47	Inches opening of damper, (U. upper) - - - - -	U. 8	U. 8	U. 8	U. 4	U. 8		

Forty three similar tables contain the deductions relative to the various kinds of fuel assayed. Many very important facts are recorded in the tables of daily observations, applicable to the elucidation of questions indirectly involved in these experiments. Those relating to the expansion of water above 212° are particularly deserving of notice for the relation they bear to the causes of steam boiler explosions. The greatest care seems to have been taken to make the observations on this subject correct, as it was important to be able to determine the volume of the water at any given temperature that would correspond with the same quantity at the normal temperature, and to assure the observers that the boiler contained the same weight of water at the beginning and end of an experiment.

These observations thus made, merely for the correcting of those on the weight of water supplied, and not under the influence of any theoretical views, are scarcely systematic enough for the establishment of a general law, but they lead strongly to the inference that a general law does exist for the expansion of water above 212°, and that the ratio of that expansion increases with a rapidity not generally suspected. It is a subject preëminently worthy of more careful investigation; and its importance in a practical point of view is not diminished by the fact that a part of the apparent dilatation is due to the constant admixture of steam, throughout the mass of water, while in ebullition. Assuming the general fact to be true, that water under high temperatures and pressures does expand in a rapidly increasing ratio, we have the means of solving some of the most serious difficulties attending the explanation of the causes of many disastrous steam boiler explosions, and particularly those of the high pressure character, on our western waters. The following note from page 13 of the Report, will give a condensed view of the facts collected on the subject of expansion of water by heat.

"The observations made on the gradual rise of temperature, and the correspondent weights of water which it took to fill the boiler, as much as the expansion by heat did, gave the following table. The weight of water operated on was 12,795 lbs.

From 66° to 114½°,	viz.	48°·5,	the increase	= bulk of	69 lbs. at 58°,	or 1·42 lbs.	to 1°
114½ to 149	"	34°·5,	"	"	81 "	or 2·35 "	to 1
149 to 180	"	31	"	"	97 "	or 3·13 "	to 1
180 to 207	"	27	"	"	86 "	or 3·18 "	to 1
207 to 223	"	16	"	"	89 "	or 5·56 "	to 1
223 to 230	"	7	"	"	71 "	or 10·14 "	to 1

"This great increase in the rate of expansion of water above the boiling point, being nearly 7¼ times as great in the range of the last 7° as in the first stage of 40°, may probably possess some interest beyond that which attaches to it as a means of correcting the results of certain observations taken during this research. The subject has not, to my knowledge, attracted much attention among experimenters. It will be remarked, that this rapid augmentation of the rate of dilatation of water, in iron is not prevented by the conversion, at the same time, of a considerable quantity of water into steam of a high density."

A synoptical table of the character, composition and efficiency of each *class* of coals follows the tables relating to each member of that class. The following, relating to the bituminous coals of Virginia, near Richmond, we introduce also as the best means of exhibiting its object and importance.

Synoptical view of the characters, composition, and efficiency, of Virginia bituminous coals.

Designation of coals.	Density.						Composition in 100 parts.						
	Specific gravity.	Pounds per cubic foot, calculated from specific gravity.	No. of experiments to determine actual weight.	Weight, in pounds per cubic foot, by *experiment.*	Ratio of actual to calculated weight.	Cubic feet of space required to stow one ton.	Moisture, determined by steam-drying apparatus.	Volatile matter, other than moisture.	Sulphur.	Fixed carbon.	Coke.	Earthy matter.	Ratio of fixed to volatile combustible matter.
Barr's Deep Run, - - - -	1·382	86·410	48	53·174	0·6153	42·126	1·785	19·782	–	67·958	78·433	10·475	3·435
Crouch & Snead's, - - - -	1·451	90·710	36	53·593	0·5908	41·797	1·785	23·959	0·427	59·976	74·256	14·280	2·499
Midlothian (900 feet shaft) average coal, - - - - -	1·437	87·497	34	50·518	0·5773	44·340	1·172	27·278	–	61·083	71·550	10·467	2·239
Creek Company's coal, - -	1·319	82·480	41	46·496	0·5636	48·170	1·450	29·678	2·890	60·300	68·872	8·572	2·032
Clover Hill, - - - - - - -	1·285	80·355	42	45·485	0·5660	49·250	1·339	31·698	0·514	56·831	66·963	10·132	1·793
Chesterfield Mining Company,	1·289	80·565	43	45·549	0·5653	49·180	1·896	30·676	1·957	58·794	67·428	8·634	1·917
Midlothian, average, - - -	1·294	80·895	42	54·044	0·6680	41·450	2·455	29·796	0·058	53·012	67·749	14·737	1·780
Tippecanoe, - - - - - - -	1·346	84·140	55	45·100	0·5360	49·670	1·841	34·165	0·377	54·620	63·994	9·374	1·599
Midlothian, "new shaft," -	1·325	82·815	31	47·899	0·5811	46·760	0·670	33·490	2·286	56·400	65·840	9·440	1·684
Midlothian, screened, - - -	1·283	80·210	46	45·722	0·5700	48·990	1·785	34·497	0·202	54·063	63·718	9·655	1·567
Midlothian, (navy yard,) -	1·390	86·855	15	54·468	0·6271	41·125	1·014	28·736	2·380	56·112	70·250	14·138	1·953

Synoptical Table, (continued.)

Designation of coals.	Combustion.				Action of furnace during steady pressure.					Evaporation.					
					Mean temperature						Pressure.		Water supplied per hour during steady action,		
	Total No. of pounds consumed.	Pounds supplied per hour, during steady action.	Pounds per square ft. of grate surface per hour during steady action.	Pounds evaporating one cubic foot of water.	Of air, on arriving at grate.	Of gases, on arriving at chimney.	Gained by the air, before reaching grate.	Of escaping gases above that of steam in boiler.	Draught-gauge—height, in inches, of water.	Time required to bring boiler to steady action, in hours.	In atmospheres, above a vacuum.	In pounds per square inch, above 1 atmosphere.	In pounds.	In cubic feet.	In pounds per sq. foot of absorbing surface of boiler.
Barr's Deep Run,	5072·75	106·93	7·600	7·992	222·87	328·68	163·02	96·53	0·382	1·520	1·436	6·444	838.93	13·421	2·218
Crouch & Snead's,	3834·75	97·90	7·133	8·576	199·66	306·87	133·71	81·78	0·359	1·158	1·417	6·165	724·41	11·649	2·071
Midlothian (900 feet shaft) average coal,	3417·50	122·10	8·678	8·348	247·13	348·61	179·90	114·90	0·367	1·383	1·421	6·222	907·11	14·513	2·403
Creek Company's coal, - - - -	3769·63	120·94	8·595	8·445	276·49	337·89	196·76	114·14	0·318	1·166	1·431	6·367	930·40	14·885	2·464
Clover Hill, - -	3775·10	89·56	5·843	9·340	362·51	302·54	297·95	74·81	0·145	1·933	1·416	6·144	521·89	8·348	1·382
Chesterfield Mining Company, - -	3876·00	119·02	8·459	9·069	252·01	344·58	172·28	113·72	0·299	1·166	1·437	6·461	909·74	14·467	2·409
Midlothian, av'rage,	4506·39	90·27	6·676	8·756	247·72	289·01	171·89	65·07	0·214	1·516	1·436	6·441	630·71	10·091	2·019
Tippecanoe, - -	4904·75	108·95	7·369	9·361	325·25	302·15	266·66	72·11	0·231	1·333	1·426	6·291	663·59	10·622	1·757
Midloth. 'new shaft'	2918·50	108·33	7·604	8·132	263·23	306·39	186·63	75·12	0·322	0·905	1·419	6·188	844·38	13·460	2·229
Midloth., screened,	4132·00	86 22	6·239	8·001	285·65	297·78	216·95	70·63	0·179	1·289	1·425	6·283	632·10	10·113	1·674
Midlothian, (navy yard,) - - -	1463·50	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Synoptical Table, (continued.)

Designation of coals.	Evaporation.						Residue from furnace.				Lead reduc'd fr'm litharge	
	Steam, in pounds, corrected for temperature of water in cistern, to				Effect of open air-plate: (+*gain*, −*loss*.)							
	One of fuel, from initial temperature.	One of fuel, from 212°.	One cubic foot of fuel, from 212°.	One of combustible matter, from 212°.	On economy of fuel, per cent.	On rapidity of evaporation, per cent.	Total of clinker and ashes, from 100 of fuel.	Clinker alone, from 100 of fuel.	Ratio of clinker to total waste.	Pounds of unburnt coke, after each trial.	By one of fuel.	By one of combustible matter.
Barr's Deep Run, - - - -	7·845	9·018	478·74	10·142	− 5·056	− 7·584	11·073	4·748	0·4288	6·400	24·620	28·007
Crouch & Snead's, - - - -	7·298	8·345	445·02	9·740	+ 2·990	− 6·802	14·340	5·371	0·3752	6·000	19·617	25·775
Midlothian (900 feet shaft) average coal, - - - - - -	7·499	8·584	433·73	9·611	− 2·613	+ 6·634	10·702	6·466	0·6045	5·917	25·035	26·993
Creek Company's coal, - -	7·444	8·417	391·85	9·211	+15·017	+32·179	8·641	4·415	0·4984	10·530	28·100	30·523
Clover Hill, - - - - - -	6·713	7·675	347·44	8·588	− 6.633	−25·979	10·601	3·859	0·3680	11·512	26·962	28·527
Chesterfield Mining Company,	7·949	8·998	410·89	9·896	+ 1·623	− 1·895	9·069	4·189	0·4628	10·469	25·784	27·376
Midlothian, average, - - -	7·303	8·295	448·46	9·741	+ 0·152	−21 610	14·827	8·821	0·5954	6·442	27·344	29·027
Tippecanoe, - - - - - -	6·743	7·748	350·23	8·583	+ 7·994	+11·345	9·723	4·034	0·4150	11·250	27·958	29·170
Midlothian, "new shaft," -	7·665	8·750	418·61	9·751	+ 2·653	+ 6·217	10·258	4·214	0·4218	17·083	25·084	26·797
Midlothian, screened, - - -	7·836	8·944	408·72	9·970	+ 3·471	+ 0·190	10·271	3·329	0·3242	14·800	27·285	29·745
Midlothian, (navy yard,) - -	–	–	–	–	–	–	20·100	4·424	–	43·250	25·130	27·230

Four of these synoptical tables will be found in the Report.

Prof. Johnson having in these experiments the most satisfactory means of determining the practical heating power of coal, was led to inquire whether the celebrated process of Berthier, by the reduction of litharge, could be depended upon as a means of determining analytically the same question. The facts resulting from these experiments are recorded in the two last columns of these synoptical tables. They are collected in a tabulated form in other parts of the Report, and show unfortunately that implicit confidence cannot be placed in this process.

The following extract indicates a much more plausible means of determining this question by analysis than that of Berthier or others, and is in every respect worthy the attention of experimenters.

" *Heating powers derived from ultimate analyses of coals.*

" The comparisons which in the course of this Report I have been enabled to make between the practical steam-generating power of the *combustible matter* of several kinds of coal, and that derived from their ultimate analysis, and thence calculated from the quantity of carbon which they severally contain, enable me to offer at present the following cases illustrative of this subject. Should I be hereafter empowered to complete the series of researches so as to obtain ultimate analyses of all the coals which have been tested by evaporation, a mass of evidence would be accumulated, which might, in all probability, set the question finally at rest.

	Evaporative power of 1 of combustible matter by steaming apparatus.	Power calculated from *carbon* ascertained by ultimate analysis.
Cambria county, Pennsylvania, - -	11·550	11·522
Midlothian, (new shaft,) Virginia, - -	11·460	11·731
Newcastle, England, - - -	10·898	10·545
Clover Hill, Virginia, - - -	10·537	10·445
Scotch, - - - - -	10·206	10·393
Indiana (Cannelton), - - -	9·557	9·509
Mean, - - -	10·701	10·691

" Notwithstanding this very remarkable approximation (or, I may say, identity) of the two numbers in these six instances, I would not be understood as announcing the universality of the law that the weight of carbon alone in coal is the only available element of its heating power. I only bring forward this number of facts, all tending in the same direction, all in harmony with each other and with preëxisting experience, so far as any tolerable degree of exactness has been given to researches in relation to this subject.

" In the works of European chemists, the calculated 'heating power' of coals is ascertained by the numbers for hydrogen and carbon determined by Despretz and Dulong. In Peclet's work, Pennsylvania anthracite has assigned to it a heating power represented by 7211° centigrade, or 12980° Fahr.; Newcastle coal 7866° cent., or 14159° Fahr. Now, in *practice*, 8 kinds of Pennsylvania anthracite gave a mean evaporative power of 9·56, and Newcastle coal gave 8·66."—p. 586.

Evincing his habitual care in expressing an opinion, Professor J. hesitates to assert at once that the "carbon alone in the coal is the only available element of its heating power." This certainly indicates a degree of prudence worthy of imitation, and it is earnestly to be hoped that he may be empowered "to complete the series of researches" on this as well as other subjects connected with this important material, coal. For it must be evident that the establishment of this law as unquestionable, is in the highest degree interesting. No other analytic process has yet been found satisfactory, and experiments on a practical scale require too much time and money to make them as these have been made under the direction of Prof. Johnson, to allow them to be undertaken on private account.

With the view of showing the reader the manner in which Prof. Johnson treats that part of the subject which relates to the analysis of coals, we introduce the following extract, relating to the second specimen of the coals in the above table.

"*Bituminous screened coal from the mines of the Midlothian Coal Company's 'new shaft,' Virginia.*

"This sample was received and used in the lump form, which it retained with considerable force. Its fractures present a shining black resinous, scarcely conchoidal aspect, with distinct lines of the laminæ of deposition. It is mostly free from incrustations of earthy matter, but occasionally presents some shaly or pyritous portions.

"The powder is of a light brown, indicating a pretty high degree of bituminousness; and its streak is nearly of the same color.

"The specific gravity of two specimens (*a* and *b*) was found to be 1·3495 and 1·3006, respectively; the mean of which affords by calculation the weight of one cubic foot of the coal in the solid state = 82·43 pounds.

"By thirty one trials in the charge-box, the mean weight per cubic foot was ascertained to be 47·899 pounds—the lowest result being 42·75, and the highest 54·125. Hence the actual is to the calculated weight as 0·5811 to 1.

"The space required for the stowage of one gross ton is 46·769 cubic feet.

"In the analysis of specimen *a*, the moisture was found to be 0·74 per cent., and that of *b*, 0·914 per cent. In the steam-drying apparatus 28 pounds lost in three days only three ounces, or 0·6696 per cent.

"The sulphur in *b* was 2·282 per cent.

"Of volatile matter, other than moisture, *a* had 34·72, and *b* 31·556 per cent.

"The coking took place with the emission of a beautiful bright flame. This indicated a large proportion of olefiant gas, and the absence of carbonic acid, or other incombustible gaseous matter. Two specimens tried by Dr. King gave a mean of 35·75 per cent. of volatile matter, including moisture.

"The incineration of *a* produced 9·549, and that of *b* 5·48 per cent. of the raw coal. Hence the composition of the two may be thus represented:

	Specimen *a*.	Specimen *b*.
Moisture - - - -	0·740	0·914
Sulphur - - - -	(not tried.)	2·282
Volatile combustible - - -	34·720	29·274
Earthy matter - - -	9·549	5·480
Fixed carbon - - - -	54·991	62·050
	100·	100·
Volatile to fixed combustible,	1 : 1·584	1 : 1·966

"The quantity of coal burned during the three trials of evaporative effect was 2918·5 pounds.

"The waste matter withdrawn consisted of—

Ashes, (including 1·932 pounds of wood ashes) -	175·25 pounds.
Clinker - - - - -	126·25 "
Soot - - - - - -	14·00 "
The *ashes* lost by re-incineration - -	16·18 per cent.
The *clinker* - - - - -	0·00 "
The *soot* - - - - -	56·75 "

"Reducing the ashes and soot in these proportions, and deducting the wood ashes, we have left 277·4—1·932=275·473 pounds of absolutely incombustible matter, or 9·44 per cent. of the coal consumed. The trials in the large way show this coal to consist of—

Moisture, from 28 pounds - - - -	0·6696
Other volatile matter, from four specimens - -	33·4904
Earthy residuum, from 2918·5 pounds - - -	9·4400
Fixed carbon, by difference - - - -	56·4000
	100·

The volatile is, therefore, to the fixed combustible as 1 : 1·684

The weight per cubic foot of the

Ashes, was - - - - -	56·65 pounds.
Clinker - - - - - -	30·12 "
Soot - - - - - -	5·46 "

"The clinker is brown on the outside; but on the fractured surfaces black, very compact, and heavy; in sheets of considerable extent, manifestly very fusible, and tending to adhere to the grate. The highly ferruginous character which it presents, is in accordance with the large amount of sulphur which was detected in one of the specimens above analyzed.

"The shaly portions embraced in the vitrified clinker are nearly obscured by the fusible coating which encloses them.

"A portion of the specimen *b*, above analyzed, was subjected to treatment with the oxide of copper: 4·57 grains were thoroughly dried; and the result of their treatment, with all the precautions required by the experiment, was of *water* 2·23, and carbonic acid 14·82 grains.

"The *earthy matter* of the raw coal having been determined, as also the moisture, by previous experiments already detailed, it is easy to calculate the weight of earthy matter in 4·57 grains of *dried* coal to be 0·25274 grain, which leaves of combustible matter 4·31726 grains; the hydrogen, by analysis, is 0·24777, the carbon 4·04182 grains; leaving for oxygen and azote only 0·02767, or the relation of these three to their sum is—

Carbon - -	$\frac{4\cdot04182}{4\cdot31726}$	$= 93\cdot6200$	$= 15\cdot60$ C.	in atoms.
Hydrogen - -	$\frac{0\cdot24777}{4\cdot31726}$	$= 5\cdot7391$	$= 5\cdot74$ H.	"
Oxygen and azote -	$\frac{0\cdot02767}{4\cdot31726}$	$= 0\cdot6409$	$= 0\cdot80$ O.	"
		100·		

"In the raw coal, this analysis enables me to state that the ingredients are—

Moisture - - - - - -	0·914
Carbon - - - - - -	87·634
Hydrogen - - - - -	5·372
Oxygen and azote - - - -	0·600
Earthy matter - - - - -	5·480
	100·

"That the relative amounts of carbon and hydrogen were correctly determined in the preceding analysis, was rendered highly probable by the result of another trial, in which the apparatus became injured before the combustion was complete; but the ratio of the two products to each other was very nearly the same as in the preceding trial. The carbon was 1·2736 grain against hydrogen 0·07222 grain. As the sum of the hydrogen and oxygen is 5·972 per cent., and that of sulphur 2·282, it is inferred that, in the volatile matter produced by the distillation of this coal, there will be found 29·274—5·972=23·302 per cent. of its carbon. If the heating power be calculated from the above analysis by the organic method, without taking account of the sulphur, and only deducting of the hydrogen so much as is equivalent to the oxygen present, we have the calorific power expressed by 14·596;* or in pounds of water from 212°, for 1 of coal, 14·171. This is far above the actual result of experiment. The highest evaporative power, even when allowance was made for the heat expended on the products of combustion, as well as for that employed on the steam of the boiler, was but 10·1915. This will be evident from an inspection of the table of analyses of gases from the chimney."—pp. 420–422.

Interspersed throughout this portion of the Report are many other tables and observations of scarcely less importance, but which it is not in our power to introduce. At page 213 will be found a "Tabular view of the proximate composition of Welsh furnace coals," with a general description of the exterior and other characters of these coals. This table is highly interesting from the facility it gives us of comparing these with American coals of similar constitution.

At page 584 is a table showing the "relative heating power of different bituminous coals as tested in making chain cable, compared with their evaporative powers." This embodies the results of a series of experiments made in the smith's shops of the navy yard simultaneously with those performed to prove the evaporative powers of the several kinds of fuel. This is followed by

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* Thus the carbon is 0·87634 of the coal, (considering all that was collected in the potash tube as carbonic acid;) and this multiplied by 12,906, (Dulong's result for the heating power of carbon,) we have left 11,284 for the computed heating power of the carbon in the coal. This divided by 1·030 gives the steam generating power to 1 of coal=10,955. Deducting one eighth of 0·600 (the oxygen) from 5·372, we get 5·297; and multiplying by 62,535, (the heating power of hydrogen,) we obtain 3·312, and the sum of these is 14,596, as above. By deducting the moisture (0·6696 per cent.) and the *waste* left in the third trial of this coal, (10·397 per cent.) we have the remainder 88·933 per cent. of combustible matter, by which the total evaporative effect 10·1915 must have been produced. Hence 10·1915÷0·88933=11·460=the evaporative power of the unit of matter actually burned in that experiment. Again: as in the sample analyzed, the *combustible part* is 0·87634+0·05372+0·00600=0·93606, the *carbon* is 0·87634÷0·93606=0·9362 of that combustible; and 0·9362×12906=12083, the *heating power* of the carbon in 1 of this combustible; and, finally, 12083÷1030=11·731=its *evaporative power.*"

another table and remarks on the "average reductive powers of American and foreign coals as tested by litharge;"—the 'foreign' coals referred to consisting of anthracites, free-burning and bituminous coals of France, tested by M. Baudin.

The details of the organic analysis of coal from Caseyville, Ky., and from the Osage River, Mo., are full and satisfactory, and serve to show the ordeal to which all the others would have been subjected, had time and other circumstances permitted. Unfortunately neither of these two coals was in quantities sufficient to be submitted to experiments under the boiler.

Table CXC, exhibits the "proportion of the several *waste materials* from the furnace compared with the weight of fuel burned, showing also the composition and density of each material." The next table exhibits the "effect on the evaporative power of the unit of combustible matter, produced by closed and open air plates at the furnace bridge." The next the "effect of open air plates on the *rates of evaporation* in the boiler when using different kinds of coal." But that one which we think the most interesting and original in its results is the table "exhibiting the analysis, proportions, and heat-absorbing powers of gases from combustion." These analyses were frequently repeated, as will be seen by reference to the column of remarks in the table of daily observations, and made during the progress of the combustion of the material in the grate, by drawing the gaseous products of that combustion directly from the flues. From the data thus obtained, and by a series of laborious calculations, based upon the best established coëfficients of the specific heat of the several products, the amount of the evaporative power of the fuel thus disposed of was calculated. This added to the amount rendered efficient in the generation of steam, gives the "total calculated evaporative power to 1 of fuel from 212°. We cannot leave this subject without recommending this table to the careful study of those who may hereafter make experiments on this subject. With a well constructed furnace, stack, and chimney, and an apparatus not very complicated, the efficiency of a fuel disposed of in this way may be as satisfactorily determined as that which is spent in generating steam.

The following short table we have constructed from Prof. J.'s remarks to convey an idea of the kind of information derivable from the experiments on gases just referred to:

Table exhibiting the per centage of volatile matter in the combustible part of several classes of coals, and the evaporative power of the same part, with the proportion which was expended respectively on the boiler and on the gases passing to the chimney.

Number of the class.	Kind of coal.	No. of samples of each kind entering into the comparison.	Volatile matter in 100 of *combustible ingredients* of each kind of coal.	Incombustible matter in 100 of coal.		Number of analyses of gases made to determine the quantity of heat absorbed by the products of combustion.	Evaporative power of 1 part by weight of *coal*,			Total evaporative power of one part by weight of *combustible matter* in each kind of coal.
				Ashes and clinker.	Moisture.		*Applied to produce* useful effect on the boiler.	Expended on the gaseous products of combustion.	Proportion per ct. absorbed by the gases.	
1.	Pennsylvania anthracites, ...	5	3·84	7·37	1·34	12	9·508	1·996	17·4	12·59
2.	Natural coke of Virginia, ...	1	13·75	18·46	2·81	5	8·662	1·517	15·2	12·92
3.	Maryland free burning bitumin'us coals,	5	15·80	9·94	1·25	12	9·894	1·738	15·0	13·09
4.	Pennsylvania free burning bituminous coals, ...	4	17·01	13·35	0·82	9	9·620	1·470	13·3	12·92
5.	Coke of Virginia (Midlothian) coal,	1	17·15	16·54	2·81	1	8·632	1·193	12·2	12·10
6.	Foreign bituminous,	3	31·75	8·14	2·16	8	8·252	1·756	17·6	11·18
7.	Virginia bituminous,	5	36·63	10·74	1·64	12	8·482	1·746	17·1	11·51
8.	Cannel, ...	2	39·37	7·61	2·80	5	7·219	1·501	17·2	9·73

If there be one peculiarity more striking than another in Prof. Johnson's labors it is their *useful* tendency. After invoking the most profound principles of natural and chemical philosophy for the investigations, the result is depicted in such a manner as to admit of application by the merest practical inquirer. It may perhaps, by persons who have not duly reflected on the matter, be charged against this, as we believe it has been against some reports on other subjects of a somewhat similar character, that he indulges too much in detail in the publication of his facts. This we think an unfounded charge, tending only to encourage a course of loose investigations, injurious to the rigid laws of truth. No man should undertake the investigation of any important subject without being thoroughly prepared in every respect; but however conscious he may be of having made that preparation, he is bound to convince the rest of the scientific world of the fact before he can demand confidence in his deductions. Professor Johnson has, we think, very properly pursued this course. He presents a full description of the apparatus, of the subjects operated upon, the daily and other observations of facts as they occurred and were originally recorded, with the *formulæ* by which the deductions obtained from these facts were worked out. He who has any doubt of the correctness of these, has thus before him all the materials necessary to make his own calculations and deductions. There is no begging of confidence, no dogmatic assumption of superior knowledge, no mere enunciation of *ex cathedra* opinions.

Table CC, exhibiting a synoptical view of the character and efficiency of the several coals, and table CCI, showing the ranks of the various coals according to the several practical characters, may be considered as the summation of the relation and useful properties of these different kinds of fuel, exhibited in the most distinct practical point of view. We shall present the entire of the former table, because it contains valuable information, to which those may refer who have not the Report.

Table CCI is so arranged as to show the rank of the coals, 1st, as to relative weight; 2d, rapidity of ignition; 3d, completeness of combustion; 4th, evaporative power under equal weights; 5th, evaporative power under equal bulks; 6th, evaporative power of combustible matter; 7th, freedom from waste in burning; 8th, freedom from tendency to clinker; 9th, maximum evaporative power under given bulks; 10th, maximum rapidity of evaporation.

These tables show that no one coal presents all the qualities necessary to place it at the head of every rank, and that therefore a judicious selection is necessary to secure such as may be required for peculiar application.

TABLE CC.—*General synoptical table of the character and efficiency of the several coals.*

Designation of coals.		Specific gravity.	Weight per cubic foot, calculated from specific gravity.	Weight per cubic foot, by experiment.	Ratio of actual to calculated weight.	Cubic feet of space required to stow a ton.	Volatile combustible matter, in 100 parts.	Fixed carbon, in 100 parts.	Earthy matter, in 100 parts.	Ratio of fixed to volatile combustible matter.	Total weight of coal consumed.	Pounds burned on a square foot of grate per hour.	Hours required to bring the boiler to steady action.	Cubic feet of water evaporated per hour during steady action.	Pounds of steam to 1 lb. of coal from initial temperature.	Pounds of steam to 1 of coal from 212°.	Pounds of steam furnished by 1 cubic foot of coal.	Total waste in the state of ashes and clinker from 100 of coal.	Weight of clinker alone from 100 of coal.	Average weight, in lbs., of unburnt coke left on the grate after each experiment.	Parts of lead reduced from litharge by 1 of combustible matter of the coal.	Steam from 212° from 1 of combustible matter.
Beaver Meadow, slope No. 3,	Pa.	1·610	100·645	54·93	0·546	40·78	2·38	88·94	7·11	37·31	3944·5	6·69	3·87	12·57	8·20	9·21	505·5	11·96	1·01	112·4	32.41	10·462
Beaver Meadow, slope No. 5,	Pa.	1·551	96·93	56·19	0·580	39·86	2·66	91·47	5·15	25·36	4250·5	6·27	2·42	10·66	8·76	9·88	556·1	6·74	0·60	61·2	33·29	10·592
Forest Improvement, - -	Pa.	1·477	92·31	53·66	0·581	41·75	3·07	90·75	4·41	29·75	3810·0	6·52	3·32	12·89	8·92	10·06	440·8	6·97	0·81	40·2	33·39	10·807
Peach Mountain, - - -	Pa.	1·464	91·51	53·79	0·588	41·64	2·96	89·02	6·13	30·09	7371·9	6·69	3·54	14·04	8·96	10·11	545·7	6·97	3·03	26·6	33·49	10·871
Lehigh, - - - - -	Pa.	1·590	99·39	55·32	0·557	40·50	5·28	89·15	5·56	16·87	3838·2	6·95	3·27	11·63	7·73	8·93	494·0	7·22	1·08	36·1	28·92	9·626
Lackawana, - - - -	Pa.	1·421	88·84	48·89	0·550	45·82	3·91	87·74	6·35	23·13	4112·5	6·45	2·67	11·92	8·56	9·79	477·7	8·93	1·24	57·2	33·53	10·764
Lyken's Valley, - - -	Pa.	1·389	86·82	48·56	0·559	46·13	6·88	83·84	9·25	12·34	2471·0	6·92	2·63	12·89	8·43	9·46	459·6	12·24	4·40	18·0	32·60	10·788
Beaver Meadow, (navy yard,)	Pa.	. . .	. . .	55·08	. . .	40·65	. . .	. . .	8·10	. . .	1897·3	4·63	5·08	9·42	7·86	9·08	500·0	8·10	1·40	107·1	. . .	9·881
Natural coke of Virginia, -	Va.	1·323	82·70	46·64	0·564	48·03	12·44	75·08	11·83	6·27	4209·0	8·15	1·74	12·56	7·47	8·47	395·3	18·46	5·31	60·9	32·49	10·389
Coke of Midlothian coal, -	Va.	. . .	. . .	32·70	. . .	68·50	. . .	. . .	16·55	. . .	1037·0	9·64	2·00	16·50	7·40	8·63	282·6	16·54	10·51	53·2	. . .	10·343
Coke of Neff's (Cumberland) coal,	Md.	. . .	. . .	31·57	. . .	70·95	. . .	. . .	13·34	. . .	994·2	8·43	1·17	14·91	7·85	9·00	284·0	13·34	3·55	43·7	. . .	10·381
Mixture, one-fifth Midlothian and four-fifths Beaver Meadow, -		. . .	. . .	54·29	. . .	41·26	. . .	. . .	8·88	. . .	2050·0	5·83	3·21	10·06	7·69	8·86	481·1	8·88	4·91	9·5	. . .	9·725
Mixture, one-fifth Cumberland and four-fifths Beaver Meadow, -		. . .	. . .	54·51	. . .	41·09	. . .	. . .	8·18	. . .	2074·0	7·98	2·25	12·81	7·97	9·18	498·5	8·18	3·09	16·0	. . .	9·997
New York and Maryland Mining Company's, - - -	Md.	1·431	89·44	53·70	0·600	41·71	12·31	73·50	12·40	5·97	2127·7	6·28	1·33	12·79	8·65	9·78	524·8	12·71	5·43	10·1	30·33	11·208
Neff's Cumberland, - -	Md.	1·337	83·28	54·29	0·652	41·26	12·67	74·53	10·34	5·88	4318·4	7·86	1·68	14·80	8·19	9·44	512·7	10·96	4·53	6·1	30·72	10·604
Easby's "Coal-in-Store," -	Md.	1·307	81·69	53·47	0·655	41·90	14·98	76·26	8·08	5·09	1158·0	6·04	1·75	12·73	8·88	10·02	535·6	8·38	1·33	18·2	32·69	10·935
Atkinson & Templeman's, -	Md.	1·313	82·09	52·92	0·645	42·33	15·53	76·69	7·33	4·94	2318·2	7·33	0.99	15·70	9·47	10·70	566·2	7·96	2·12	5·1	30·06	11·624
Easby & Smith's, - - -	Md.	1·332	83·26	51·16	0·614	43·78	15·52	74·29	9·30	4·79	4474·5	8·02	1·52	14·97	8·69	9·96	511·1	9·69	3·04	5·3	33·01	11·034
Cumberland, (navy yard,) -	Md.	1·414	88·40	53·29	0·603	42·04	14·87	70·85	14·98	5·00	. . .	. . .	. . .	. . .	. . .	. . .	. . .	14·53	2·29	13·5	27·98	. . .
Dauphin and Susquehanna, -	Pa.	1·443	90·19	50·54	0·560	44·32	13·82	74·24	11·49	5·37	2557·0	6·86	0·83	13.35	8·31	9·34	472·8	16·36	3·50	23·7	31·18	11·171
Blossburg, - - - - -	Pa.	1·324	82·73	53·05	0·641	42·22	14·78	73·11	10·77	4·95	4295·0	7·77	0·84	15·67	8·64	9·72	515·9	11·20	3·40	13·7	32·54	10·956

TABLE CC, CONTINUED.

Designation of coals.		Specific gravity.	Weight per cubic foot calculated from specific gravity.	Weight per cubic foot, by experiment.	Ratio of actual to calculated weight.	Cubic feet of space required to stow a ton.	Volatile combustible matter, in 100 parts.	Fixed carbon, in 100 parts.	Earthy matter, in 100 parts.	Ratio of fixed to volatile combustible matter.	Total weight of coal consumed.	Pounds burned on a square foot of grate per hour.	Hours required to bring the boiler to steady action.	Cubic feet of water evaporated per hour during steady action.	Pounds of steam to 1 lb. of coal from initial temperature.	Pounds of steam to 1 of coal from 212°.	Pounds of steam furnished by 1 cubic foot of coal.	Total waste in the state of ashes and clinker from 100 of coal.	Weight of clinker alone from 100 of coal.	Average weight in lbs., of unburnt coke left on the grate after each experiment.	Parts of lead reduced from litharge by 1 of combustible matter of the coal.	Steam from 212° from 1 of combustible matter.
Lycoming Creek, - - -	Pa.	1·388	86·74	55·38	0·638	40·45	13·84	71·53	13·96	5·18	3073·2	6·33	1·72	12·13	7·92	8·91	493·3	16·92	3·26	46·2	32·89	10·724
Quin's Run, - - - -	Pa.	1·331	83·22	50·34	0·605	44·50	17·97	72·79	8·41	4·05	1883·2	7·29	0·75	13·90	9·08	10·27	517·0	8·94	1·31	14·7	30·90	11·275
Karthaus, - - - -	Pa.	1·284	80·22	52·54	0·655	42·63	19·53	73·77	7·00	4·11	3643·8	6·66	1·87	12·48	7·92	9·09	477·4	7·89	3·66	52·5	33·31	9·887
Cambria County, - - -	Pa.	1·407	87·94	53·46	0·608	41·90	20·52	69·37	9·15	3·66	3488·5	6·68	2·00	12·47	8·04	9·24	486·9	9·75	3·48	14·8	31·46	10·239
Barr's Deep Run, - - -	Va.	1·382	86·41	53·17	0·615	42·13	19·78	67·96	10·47	3·43	5072·7	7·60	1·52	13·42	7·84	9·02	478·7	11·07	4·78	6·4	28·01	10·142
Crouch & Snead's, - -	Va.	1·451	90·71	53·59	0·591	41·80	24·38	59·98	14·28	2·50	3834·7	7·13	1·16	11·65	7·30	8·34	445·0	14·34	5·37	6·0	25·77	9·740
Midlothian, (900 feet shaft,) -	Va.	1·437	87·50	50·52	0·577	44·34	27·28	61·08	10·47	2·24	3417·5	8·68	1·38	14·51	7·50	8·58	433·7	10·70	6·47	5·9	26·99	9·611
Creek Company's coal, - -	Va.	1·319	82·48	46·50	0·564	48·17	32·47	60·30	8·57	2·03	3769·6	8·59	1·17	14·88	7·44	8·42	391·8	8·64	4·41	10·5	30·52	9·211
Clover Hill, - - - -	Va.	1·285	80·36	45·49	0·566	49·25	32·21	56·83	10·13	1·79	3775·1	5·84	1·93	8·35	6·71	7·67	347·4	10·60	3·86	11·5	28·53	8·588
Chesterfield Mining Company's,	Va.	1·289	80·57	45·55	0·565	49·18	32·63	58·79	8·63	1·92	3876·0	8·46	1·17	14·47	7·95	9·00	410·9	9·07	4·19	10·5	27·38	9·896
Midlothian, (average,) - -	Va.	1·294	80·90	54·04	0·568	41·45	29·86	53·01	14·74	1·78	4506·4	6·68	1·52	10·09	7·30	8·29	448·5	14·83	8·82	6·4	29·03	9·741
Tippecanoe, - - - -	Va.	1·346	84·14	45·10	0·536	49·67	34·54	54·62	9·37	1·60	4904·7	7·37	1·33	10·62	6·74	7·75	350·2	9·72	4·03	11·2	29·17	8·583
Midlothian, ("new shaft,") -	Va.	1·325	82·82	47·90	0·581	46·76	35·77	56·40	9·44	1·68	2918·5	7·60	0·91	13·46	7·66	8·75	418·6	10·26	4·21	17·1	26·80	9·751
Midlothian, (screened,) - -	Va.	1·283	80·21	45·72	0·570	48·99	34·70	54·06	9·66	1·57	4132·0	6·24	1·29	10·11	7·84	8·94	408·7	10·27	3·33	14·8	29·74	9·970
Midlothian, (navy yard,) -	Va.	1·390	86·86	54·47	0·627	41·13	29·12	56·11	14·14	1·95	1463·5	. . .	. .	. . .	. .	. . .	. . .	. . .	4·42	43·2	27·23	. . .
Pictou, (from New York,) -	N. S.	1·318	82·35	53·55	0·650	41·83	27·83	56·98	13·39	2·11	4153·9	7·84	0·94	12·79	7·48	8·41	450·6	13·37	6·13	5·7	28·18	9·710
Sidney, - - - - -	N. S.	1·338	83·66	47·44	0·567	47·22	23 81	67·57	5·49	2·84	1601·1	8·31	1·18	13·85	7·01	7·99	378·9	6·01	2·24	5·9	29·15	8·497
Pictou, (Cunard's,) - -	N. S.	1·325	82 83	49·25	0·595	45·48	25·97	60·74	12·51	2·59	1962·5	9·84	0·85	16·47	7·45	8·48	417·9	12·06	6·19	3·7	26·69	9·648
Liverpool, - - - -	Eng.	1·262	78·89	47·88	0·607	46·78	39·96	54·90	4·62	1·51	3786·0	8·59	0·86	13·43	6·95	7·48	375·4	5·04	1·86	11·1	27·88	8·255
Newcastle, - - - -	Eng.	1·257	78·54	50·82	0·647	44·08	35·83	57·00	5·40	1·60	4023·0	8·03	0·84	13·75	7·68	8·66	439·6	5·68	3·14	10·7	27·55	9·178
Scotch, - - - -	Scotland.	1·519	94·95	51·09	0·538	43·84	39·19	48·81	9·34	1·26	3860·0	10·74	0·96	14·32	6·14	6·95	353·8	10·10	5·63	5·7	27·0?	7·719
Pittsburg, - - - -	Pa.	1·252	78·37	46·81	0·598	47·85	36·76	54·93	7·07	2·01	208·4	. . .	. .	10·56	7·03	8·20	384·1	8·25	0·94	9·9	28·89	8.942
Cannelton, - - - -	Ind.	1·273	79·54	47·65	0·599	47·01	33·99	58·44	4·97	1·72	2465·5	11·09	0·50	15·05	6·31	7·34	348·8	5·12	1·64	6·4	26·53	7·734
Dry Pine wood, - - - -	-	. . .	. . .	21·01	. . .	106·62	. . .	. . .	0·307	. . .	2360·5	15·87	. .	13·86	4.06	4·69	98·6	0·307	0·00	0·0	. . .	4·707

The following classified view of twenty five varieties of coal has been derived from the table of ranks above mentioned, and may serve to indicate the practical value for steam navigation of the several classes.

Class of coals.	Names of samples.	Evaporative power of *equal weights* of coal.	Evaporative power of equal bulks of coal.	Freedom from tendency to clinker.	Rapidity of action in evaporating water.	Facility of ignition, or readiness with which steam is *got up.*	Sum of the relative values in the preceding columns.
Cumberland, (Md.) Free burning, bituminous.	Atkinson & Templeman's, - -	1000	1000	282	828	505	3615
	Easby's coal in store, - - -	936	946	451	658	286	3277
	Easby & Smith's, - - -	931	903	197	886	329	3246
	New York and Md. Mining Co.'s,	914	927	111	677	376	3005
	Neff's, - - - - - - -	882	906	133	877	298	3096
	Averages, - - - -	932	936	235	785	359	3248
Anthracites of Pennsylvania.	Beaver Meadow, slope 5, - -	923	982	1000	722	207	3834
	Forest Improvement, (Schuylkill,)	940	955	741	790	150	3576
	Peach Mountain, (Schuylkill,) -	945	964	198	901	142	3150
	Lackawana, - - - - -	915	844	484	779	187	3209
	Lehigh, - - - - - - -	835	872	555	792	153	3207
	Averages, - - - - -	911	923	595	797	168	3395
Free burning bituminous coals of Pennsylvania.	Quin's Run, - - - - - -	960	913	458	726	667	3724
	Blossburg, - - - - - -	908	911	176	996	595	3586
	Dauphin and Susquehanna, - -	873	835	171	766	602	3287
	Cambria County, - - - -	863	860	172	867	250	3012
	Lycoming Creek, - - - -	833	871	184	706	291	2885
	Averages, - - - -	887	878	232	892	481	3299
Highly bituminous coals of Virginia.	Chesterfield Mining Company, -	841	726	143	1000	427	3137
	Midlothian, screened, - - -	836	722	180	730	388	2856
	Creek Company's, - - -	787	692	136	981	299	2885
	Crouch & Snead's, - - -	779	786	112	635	431	2743
	Tippecanoe, - - - - - -	724	618	149	875	376	2742
	Averages, - - - -	793	709	144	844	384	2872
Foreign bituminous coals.	Newcastle, Eng., - - -	809	776	191	827	595	3198
	Pictou, (Cunard's sample,) N. S.,	792	738	97	928	588	3143
	Sidney, N. S., - - - - -	747	669	276	764	424	2880
	Liverpool, Eng., - - - -	733	663	323	857	581	3167
	Scotch, . - - - - - -	649	625	107	847	521	2749
	Averages, - - - -	746	694	197	844	526	3027
General scale of relative values formed from the averages of each class.	Maryland free burning coals, -	1000	1000	395	880	682	
	Pennsylvania anthracites, - -	977	986	1000	893	319	
	Pennsylvania free burning bituminous, - - - - - -	951	938	390	1000	914	
	Virginia bituminous, - - -	850	757	242	948	730	
	Foreign bituminous, - - -	801	741	331	948	1000	

From the above scale it appears that in evaporative power under *equal weights*, the Cumberland class surpasses the anthracites by about 2·3 per cent., and under *equal bulks*, by 1·4 per cent. They also surpass the foreign bituminous coals 20 per cent. when we compare equal weights, and 26 per cent. by equal bulks. In freedom from clinker the anthracites stand preëminent; in rapid production of steam, when once in action, the Pennsylvania bituminous coals are somewhat superior to all others, and for *getting up* steam, the foreign bituminous coals take less time than either of the other classes.

Has the government yet availed itself of the important information which these tables present, in making its purchases? Judging from the advertisements for contracts by the navy department, we must say we fear not.

Our eastern depots, we believe, except perhaps the Washington navy yard, are supplied with anthracite for the use of steam ships; whilst those of the south have their supplies of the most bituminous character. Suppose an express shall have been received at one of our ports, that a pirate or suspicious looking cruiser has just been seen, and a steam vessel lying there shall be ordered to proceed immediately in quest of her. We see by the thirteenth column of table CC, that if every thing else is in preparation, it will require from three to four times as long to bring the steam boiler to steady evaporation by the one as the other, and therefore that difference in the time at which the steamer can be considered as performing its full duty. Again, we believe on the Mexican coast the depots are supplied exclusively with coals of the highest bituminous character, such as Cannelton, Ind. and Pittsburg, Pa. The results of the experiments show that this species of coal was admirably adapted to the short cruising and rapid running generally required on the coast; but one of these vessels may be wanted to cruise among the West Indies or along the coast of Yucatan. From the nature of this fuel, as may be seen by referring to the column "cubic feet of space required to stow a ton," and "pounds of steam furnished by one cubic foot of coal," it is evident that the bunkers of the ship filled with this kind of coal would not sustain a cruise much more than one half as long as with some of the other coals.

These are differences of character eminently worthy of the attention of the government.

We merely mention these supposed cases to show the practicable application of the information contained in this Report. Others not less important might be presented, and we hope that the departments of government will not fail to avail themselves of them. The money expended on these investigations has been well spent;—but if those whose duty it is to apply this information, fail to do so, the outlay, so far as the government is concerned, might as well have been spared. Nothing appears more absurd than an ostentatious display of a desire to obtain information, and an unwillingness or incapacity to use it when obtained.

During the last few years, the navy department has shown a very laudable desire to obtain such information as might be necessary to enable it to avail itself most successfully of the recent improvements in naval warfare. Too much credit cannot be given to those who have pursued, or who may hereafter pursue this course judiciously. It indicates a very proper conception of the importance of this arm of national defence, and incidentally leads to developments of valuable resources. As might be expected, some, perhaps many, of the experiments that have been instituted for this purpose, have not been very creditable in their results to those who proposed them, or beneficial to the government. But this must often be the case, particularly when they are not based upon strictly scientific principles. The experiments recorded in this Report, and the results deduced from them, are exposed to no such objection. The daily records show that no preconceived theory existed to give them a partial character; whilst the labor bestowed in preparing and applying the most difficult formulæ proves that the great object was truth. To obtain this no care was deemed superfluous, no labor too great. The results of the researches have moreover been reduced to so practical a condition, that they are entirely within the comprehension of the most common capacity. The eagerness with which this Report has been sought for, both at home and abroad, sufficiently indicates the great practical interest of the subject. Foreigners as well as our own countrymen, have begun to look to American coals, not only for the purposes of warlike and commercial navigation, but also as the direct materials and objects of trade.

If under any circumstances there be wisdom in the maxim,—"in peace prepare for war,"—it was doubtless a most prudent measure to place our government in possession of all information which could tend to increase the efficiency of our navy, by developing the value of our resources in coal. Within a few years past a decided improvement has been observed in the tone and temper manifested by our public authorities relative to matters affecting the public intelligence. The most ultra and bigoted no longer scout as formely the labors of science, which are alike indispensable to the movements of government, and to the success of individual enterprise, alike essential to the material interest and to the social progress of nations. The real statesmen of our country clearly perceive that scientific investigations, conducted by men specially qualified for such pursuits, are equally necessary here as in the older dynasties of Europe, and that to foster ignorance by withholding the means to increase and diffuse knowledge, is the readiest way to spread over our land the darkness and despotism of the middle ages.

Art. VIII.—(1.) *Description of a mass of Meteoric Iron, which fell near Charlotte, Dickson County, Tennessee, in* 1835; (2.) *Of a mass of Meteoric Iron discovered in De Kalb County, Tenn.;* (3.) *Of a mass discovered in Green County, Tenn.;* (4.) *Of a mass discovered in Walker County, Alabama;* by G. Troost, Prof. Chem. and Min. in University of Nashville, Tenn.; Member Phil. Soc., and Acad. Nat. Sci., Philad.; of the Geol. Soc. of France, &c. &c.

In a former memoir on meteoric iron,* I mentioned that besides the mass there described, other masses of meteoric iron had been found in the state of Tennessee,—one near Charlotte, in Dickson County, and another in De Kalb County, a few miles west of Cany Fork, near the road from Liberty to the ferry on that river. When I wrote that memoir, I had seen the latter mass, but the owner thinking that it was gold, platinum, or silver, valued it at an extravagant price; having since been convinced that it did not belong to these precious metals, I obtained it for a moderate price.

The mass from Charlotte, the county seat of Dickson County, is now also in my possession. I am indebted for it to the kindness of my friend, the Hon. J. Voorhies, senator from Dickson County in the legislature of Tennessee.

I learned after the publication of the above mentioned memoir, that another mass of this iron had been found in Green County, Tennessee, having been ploughed up in a field twelve miles from Greenfield; this also is in my cabinet, and for it I am indebted

* See this Journal, Vol. xxxiv, p. 250.

to the Hon. Judge Jacob Peck of Jefferson County, and to Mr. Estabrook, President of Knoxville College.

A fourth mass was found by Mr. Wiley Speaks in the northeast corner of Walker County, Alabama. It is also in my cabinet, through the kindness of my friend, Dr I. F. Sowell of Athens, Alabama, who purchased it for me of its discoverer.

Meteoric Iron from Charlotte, Dickson County, Tenn.

There is at present only one single instance where the fall of meteoric iron has been observed and properly authenticated. I allude to that of Agram, which fell on the 26th of May, 1751, about 6 o'clock in the afternoon, at Hraschina, a village near Agram in Croatia.* Most of this mass is in the Imperial Mineral Cabinet at Vienna, and it is not only remarkable for its authenticated fall, but also for its excellent preservation, its characteristic crust, and its well defined Widmannstattian figures, &c. All the other known masses of meteoric iron were accidentally discovered, and their meteoric origin is proved only by the characters which distinguish them from all terrestrial products. The state of Tennessee can now boast of possessing a second mass, (the fall of which was witnessed by several persons,) which is not inferior in any of the properties possessed by the Agram iron,† and which now forms one of the ornaments of my cabinet.

A member of the legislature of the state of Tennessee from Charlotte, county seat of Dickson, (I do not remember his name,) having seen my description of the Cocke County meteoric iron, mentioned to me some years ago, that a curious mass of some metal was in the possession of one of his constituents, which he thought might be of the same nature as that of Cocke County. He was not able to give me any other information, but becoming ac-

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* Von allen bekannten meteorischen eisenmassen ist die Agramer die einzige deren herabfallen sammt allen nebenamstanden beobachted worden ist, sie is sowohl indieser hinsecht als durch ihre oberflache, die rinde von doppelter beschaffenhert, die vollkommenhert der widmannstattischen figaren U. S. W. die merkwurdigste und kostbarste von allen in sammlungen aufbewahrten meteoreisenmasse. Paul Partsch.—Uber die Meteoriten oder von Himmel gefallenen steine und Eisenmsasen in K. K. Hof-Mineralien-Kabinette zu Wien. 1843, pag. 106.

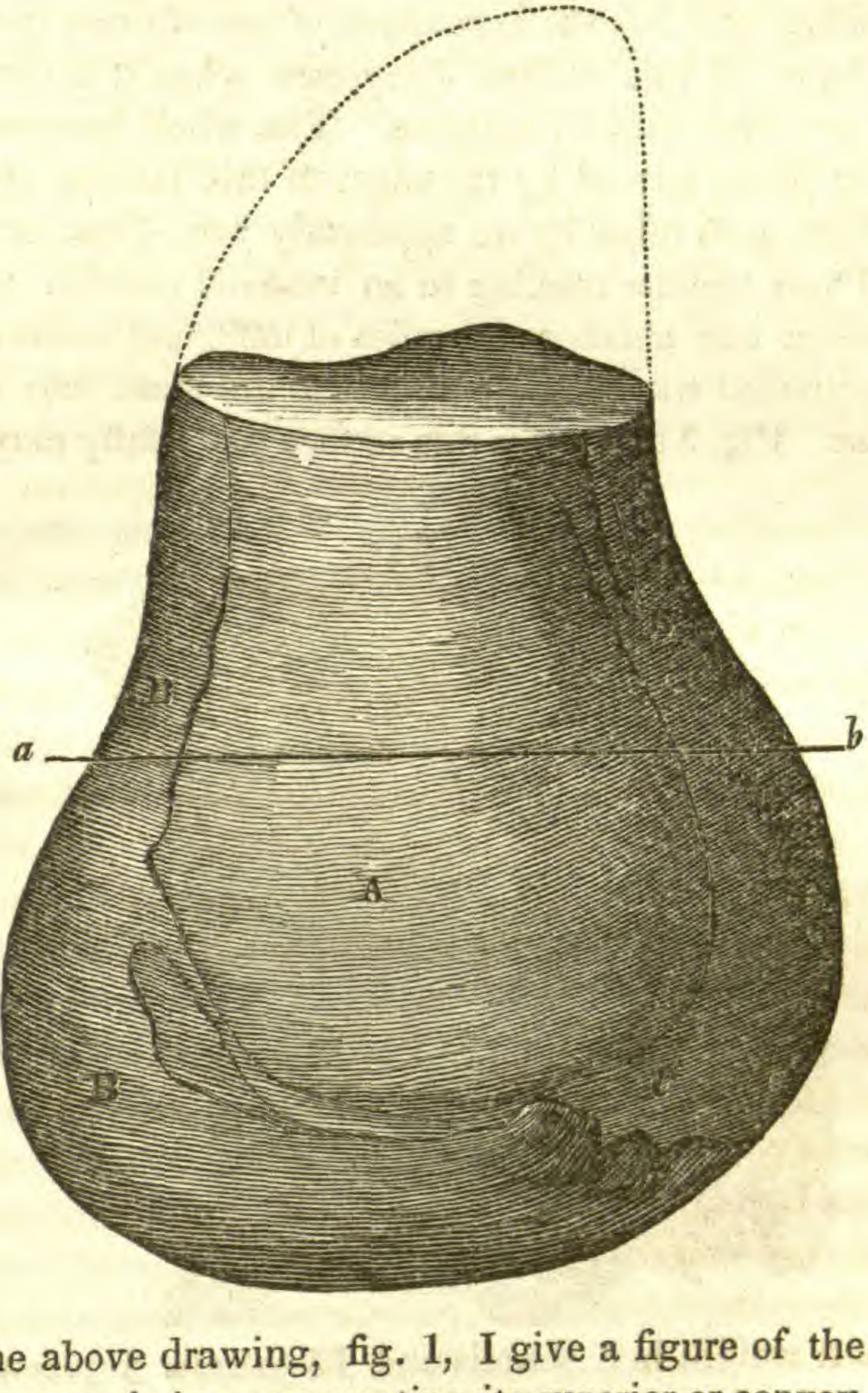
† There is a small specimen of the Agram iron in the cabinet of Yale College. Through the kindness of the late Baron Lederer it was obtained in exchange for American meteorites; it has very decidedly the characteristic crystallization.—*Eds.*

quainted since with the Hon. J. Voorhies, senator of Dickson County, I learned from him that such mass really existed, that he knew the person in whose possession it was, &c. Having thus learned that I desired to obtain it, my friend, the senator, did not rest till he had secured the specimen and put me in possession of it and its history.

I learned then the following facts from Senator Voorhies, and these facts have since been confirmed by other persons. In answer to a letter which I wrote about this iron to the senator, he answered:—"I have collected all the facts in connection with the history of the meteoric mass which I sent you last year, but I have not been able to add much to those that I have already communicated. There is no doubt that this mass fell from heaven upon the earth, where it shortly after was found, though the precise date cannot be recollected. I was told that a noise was heard in the air, which was preceded by a vivid light. This happened while several persons were laboring in their fields. A man who lives at present in this vicinity, was ploughing at the time when this took place; his horse took fright, and ran around the field dragging the plough behind him; he recollected this circumstance very well, and it enables him to fix the date upon which the fall took place. He believes that it was in 1835, on the last of July or the first of August, between 2 and 3 o'clock in the afternoon,—the sky being cloudless. It fell, before the last ploughing, in a cotton field opposite his dwelling. The iron was found when the field was ploughed for the last time that season. Its fall was not vertical but much inclined, and it travelled with great rapidity from west towards the east, as was evident from the furrow that had been made in the ground. The original shape of the mass was that of a kidney. Its smaller extremity was cut off by a blacksmith who yet lives in this vicinity. When it was first taken out of the ground, it had the appearance as if it had been heated."

According to this letter and the information which I collected at the place itself, where it fell—the Dickson iron fell, as already stated, on the last of July or the first of August, between 2 and 3 o'clock, P. M. It has the form of a drop, or rather of a depressed tear; one side is partly flat and partly concave, while the other side is convex,—the form a drop of viscid matter would assume, if it fell upon a hard floor. The surface has the appearance of smooth cast iron. It is surrounded by a zone or girdle of a metal of a whiter color, and of a more compact texture, possessing a more or less bright polish, which seems to have been produced by a more fluid part of the metal, squeezed through the pores of the already solid iron, by pressure probably occasioned by the fall, which spreading itself as a thin cover over the surface, formed the zone or girdle mentioned above.

Fig. 1.

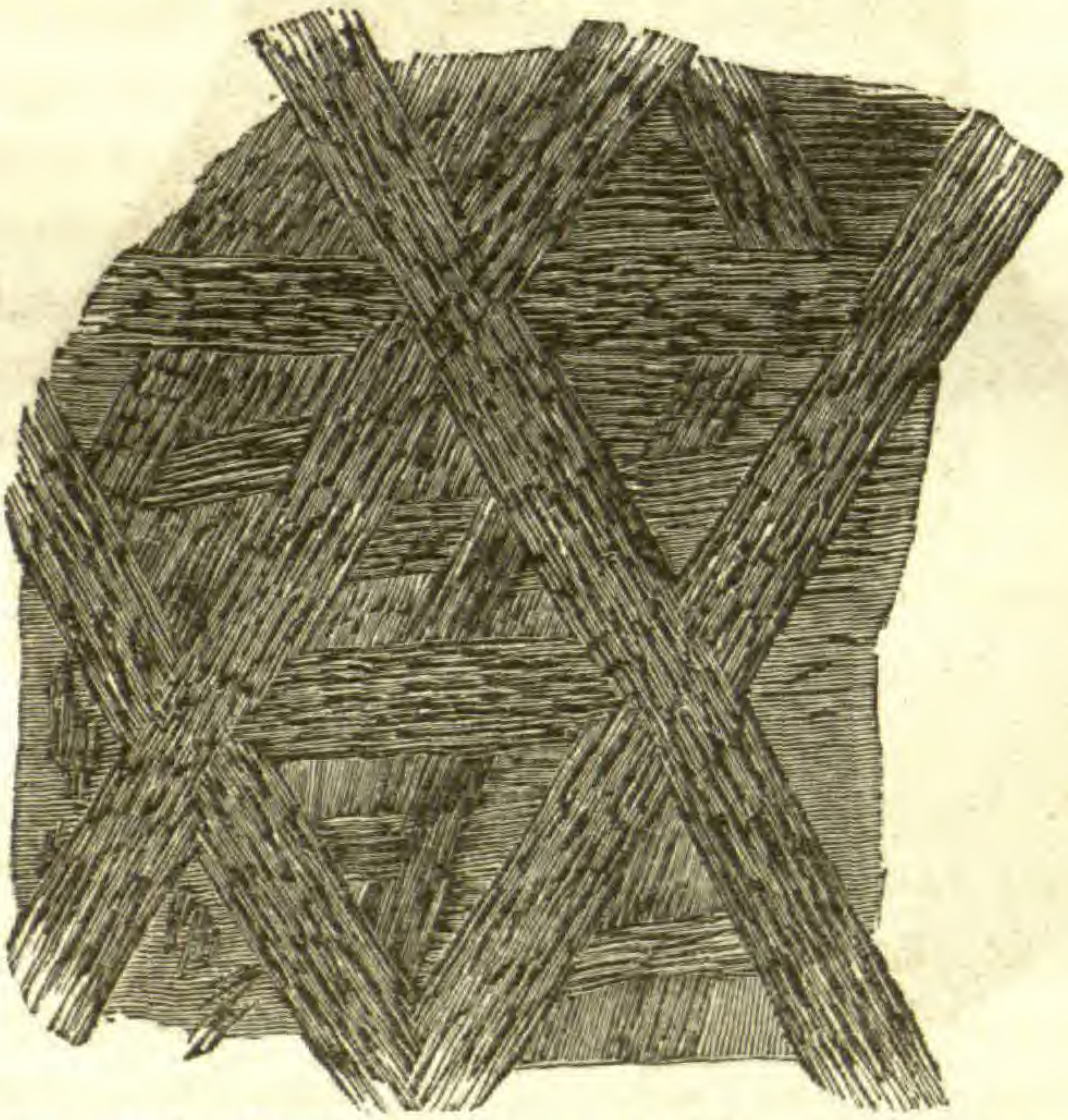


In the above drawing, fig. 1, I give a figure of the mass, in half its natural size, representing its superior or convex surface A, and the zone or girdle of white metal B B B. At C is a kind of indenture, which could have been formed by nature only in a viscid matter, occasioned by contraction during refrigeration. Fig. 2 represents a horizontal section of the mass at line *a*, *b*, fig. 1, half its natural size.

Fig. 2.
Superior surface.

As mentioned above, the surface of the mass (when viewed with the naked eye) has the appearance of smooth cast iron; but the irregularity of this surface disappears when it is examined through a powerful magnifying glass. The whole becomes then a reticulated plane, formed by the edges of thin laminæ of metal, separated from each other by an apparently semi-fused or slaggy matter. These laminæ running in an inclined position into the mass, intersect one another at angles of 60°, and consequently forming equilateral triangles, would divide the mass into regular octahedrons. Fig. 3 represents this surface powerfully magnified.

Fig. 3.



Its present weight is 7 pounds and 13 ounces. I presume the original weight, judging from the size of the piece cut off before it came in my possession must have been between 9 and 10 pounds.

Its fracture, judging from the piece that was partly cut and partly broken off before I got it, has the character of that of a very soft kind of malleable iron, showing at the same time in its jagged fracture some regularity of crystallization.

Meteoric Iron from De Kalb County, Tenn.

Nothing is known respecting the fall of this iron. The first knowledge that I received of it, was from the Hon. Judge Brown of Nashville. I went immediately to the place where it had been discovered. It had then already changed owners, and I found it in the possession of the son of the person that found it by ploughing, who lives near the mouth of the Cany Fork. I could hardly persuade this person to give me a view of it, and he did not form a very favorable opinion of my honesty when I told him that it was iron, and particularly when I spoke of purchasing it; all the answer that I could get was, "Iron, you say! I have lived too long to be cheated in this way." It was immediately locked up, and I had to depart without it. It afterwards passed through several hands, and at last the idea of its being any thing else than iron being abandoned, I was enabled to purchase it from a gun-smith, now living about 10 miles from Nashville.

Only one piece of it was discovered. Its weight when it came into my possession was about 36 pounds. Its original weight must have been greater, as several chips had been cut from the surface, by which the blacksmiths and silversmiths found out that it was not gold or silver.

When I first saw the mass, it had an ochrey-brown glossy surface, but the least scraping with an iron tool brought the natural iron color to light, so that it was not covered with a crust. It had an irregular oval shape.

This iron is remarkable for its Widmannstattian or crystalline figures, which are handsomely displayed on the section, without its being subjected to any chemical operation.* These figures are shown on the polished surface by the section of laminæ which are imbedded through the whole mass of iron. These laminæ are easily distinguished from the rest of the mass by their color, which is almost silver white; they are harder and receive a brighter polish than the bulk of the mass. When these laminæ are cut parallel to their planes, or nearly so, they exhibit only irregular spots, but where they are cut transversely, though irreg-

* These figures are produced by the action of acids, by which the more soluble part of iron is dissolved, while the less soluble part shows itself in relief upon the surface.

ularly dispersed through the iron, they exhibit a regular arrangement; they are all inclined towards each other in such manner that if they were extended till they met at the extremities, they would form equilateral triangles, so that they indicate the crystalline structure of the mass, which is that of octahedrons. In this respect it coincides with Cocke County iron.* The latter being more or less subject to decomposition, I was able to separate several of these laminæ, which have almost the color and lustre of burnished silver, and are not yet tarnished, though they have been exposed for five or six years to the influence of the atmospheric air.

There is no doubt that these pellicles or laminæ, though equally attracted by the magnet, have a different composition from other parts of the iron, and this seems to be the cause that the several analyses made of the same iron seldom give the same result.

The polished section of my cabinet specimen, offers a surface of about 7 by $4\frac{1}{2}$ inches; it exhibits in this space two large heterogeneous masses, one of about $\frac{4}{5}$ of an inch and the other about $\frac{2}{3}$ of an inch in diameter, and others smaller. I consider these masses as composed principally of graphite, intimately mixed with metallic iron, as the powder which I scraped off is feebly attracted by the magnet, and soils paper like common plumbago, and its streak has a black metallic lustre. In this respect, also, it resembles the Cocke County iron. Upon the whole it is an interesting variety.

Meteoric Iron from Green County, Tenn.

It seems that Mr. Estabrook, President of the College at Knoxville, East Tennessee, learned from Mr. Francis M. Davis of Greenville, that a mass of some metal had been found in Green County, East Tennessee. Mr. Estabrook requested Mr. Davis to secure it for him, in order to transmit it to me. Mr. Davis's answer, dated the 3d of July, 1842, is as follows:—"In compliance with your request I have obtained the mass of metal to which you refer. The whole mass that I have, weighs about 14 pounds; 6 or 8 pounds have been broken off. The form of the whole mass is very irregular, having the appearance of having been

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* See this Journal, Vol. XXXVIII, p. 251.

melted. The surface alone is oxydated, resembling very much ordinary oxydated iron. Its interior seems to be crystallized, but as to the form of the crystal, I cannot say. Its appearance is that of silver or polished steel, perfectly compact, and malleable to a great degree. It was found insulated," &c.

This piece was then divided, and part of it sent to Mr. Estabrook and part to Judge Jacob Peck. I obtained the two pieces. Judge Peck wrote me,—"The piece of iron I send you from Green County was ploughed up in a field near Babb's mill, 9 or 10 miles north of Greenville. It had been worked for the silver it contained, but the artist could not separate the silver from the other metal, because there was none in it."

It appears from the above information that this iron also was considered by its discoverer as silver, or some precious metal. It was therefore submitted to some operations in fire, which has more or less altered its surface, but I doubt very much whether it could have had any influence on its internal structure. Now this structure differs very much from that of the generality of the meteoric iron masses with which I am acquainted. In the letter above quoted, Mr. Davis says, that "*its interior seems to be crystallized;*" but this gentleman, as appears from his letter, having no mineralogical knowledge, was not well able to distinguish a crystalline from a coarse granular structure.

Its internal structure is coarse granular; its color is rather whiter than that of pure iron; and it is very malleable, equal if not superior in this respect, to the softest wrought iron; no traces of pyrites, or of any other heterogeneous substances are perceptible in it.

I doubted at first its meteoric origin, its fracture resembling that of a hard and white kind of cast iron, and its surface showing the effects of the action of fire. I submitted it therefore to analysis.

42·3 grains of it gave me,—

				per cent.
Peroxide of iron,	53·18 grs.	= Iron, (metallic)	36·87	= 87·58
Protoxide of nickel,	5·25 "	= Nickel, "	4·13	= 12·42
		Loss,	1·30	
			42·30	

Probably the quantity of nickel here mentioned is too great; perhaps it may contain some other metallic ingredients, but the state of my health at that time did not permit me to be longer engaged in chemical investigations, and therefore I did not ascertain the purity of the nickel. It was satisfactory to me that it did contain a notable quantity of nickel, and that hereby its meteoric origin was put beyond doubt. But even if the nickel had not established its meteoric origin, what could it be? I mentioned above, that in its granular structure it did resemble more or less some white cast iron, but its softness and malleability show that it cannot be that. Cast iron when it is white, is always hard and breaks under the hammer. This is not the case with our iron; I can cut small chips of it with a knife. I doubt whether this can be done from white cast iron! Its fracture distinguishes it also from wrought iron.

Meteoric Iron from Walker County, Ala.

As already mentioned, I owe the Walker County, Alabama meteoric iron to the politeness of my friend, I. F. Sowell, M. D., of Athens, Alabama, who purchased it for me from its discoverer, Mr. Wiley Speaks, living in Morgan County, Alabama. He found it in the autumn of 1832 in the northeast corner of Walker County, while on a deer-hunting excursion. He had stopped to rest upon a little spur of mountain, when he observed the mass with its large end deeply buried in the ground, leaving only a small portion of the small end protruding. Believing it to be some precious metal, he took especial pains to have it safely and secretly conveyed to his house, some 15 miles off, where it remained till February, 1843, when it came into the possession of Dr. Sowell, and shortly after I received it in Nashville.

The original weight was about 165 pounds; this weight was somewhat diminished when it came into my possession, some small pieces having been chiseled off. This must of course be expected, as these masses fall mostly into the hands of ignorant persons, who are generally on the look-out for some of the precious metals, (as silver and gold are usually called,) and consequently every thing that is uncommon is very often considered as such. It is therefore necessary, in order to convince themselves of its true nature, that some small parts of it should be sent to a silversmith.

Its shape was irregularly oval, partly covered with a brown oxydated crust, which in some places penetrated $\frac{1}{3}$ of an inch into the mass, at other places the pure iron is at the surface. The iron is very compact. Its fracture is very crystalline, exhibiting when broken triangular laminæ, some of which are about $\frac{2}{5}$ of an inch long. I doubt not, therefore, that it is susceptible of producing the Widmannstattian figures. On the polished surface of the section, several lines are perceptible; they are placed in such positions towards each other, that in case they were in contact they would form equilateral triangles.

By sawing this mass I discovered a nodule about $2\frac{1}{2}$ inches long, 2 inches broad, and $1\frac{1}{2}$ inches high. This nodule being placed near the external surface, and the saw-cut going through it, and it being separated from the generality of the mass by some thin pellicles of a white brilliant metal, as mentioned in the description of the De Kalb County iron, I could disengage it easily from the mass by some slight blows with a hammer. The part of this nodule that was imbedded, shows a very crystalline surface.

This iron is not much influenced by atmospheric agencies, but where the brown oxidized crust penetrates the mass, as observed above, some chemical action takes place. I have often found that, just at the junction of the crust with the metallic iron, during a humid state of the atmosphere, small pearls of a brown fluid would make their appearance; these fluid globules would sometimes become covered by a brown pellicle, and when the atmosphere was very dry the whole of the fluid would disappear, and nothing but the empty spherical pellicle remained. I could not conceive the cause of these fluid globules, and endeavored therefore to collect some of the fluid, thinking at the moment, of the discovery of chlorine in meteoric iron by Dr. Jackson. I brought some of it to the surface of a weak solution of nitrate of silver, and immediately a small stream of a white color went to the bottom; of course here I had the chlorine. This chlorine does not exist in the iron. To convince myself of this, I took some filings of it, (between 5 and 6 grains,) and having saturated some pure nitric acid with them, dropped it into a similar solution of silver as above; no precipitate ensued. I made experiments, also, with the little fluid globules, in the presence of Prof. Litton, with the same result.

In examining the action of the magnetic needle on the oxidized crust of the Alabama iron, I found that most of this crust was attracted by the magnet, and that some of it exhibited constantly a powerful polarity, and attracted iron filings. On this occasion I examined the magnetism of some large pieces of meteoric iron which had a polished surface. I found when these surfaces were placed vertically, that invariably the north pole of the needle was attracted by the upper edge, and the south pole by the lower one; and moving the needle from the upper toward the lower edge, along the surface, without being in contact with it, I arrived at a place where neither of the poles was attracted; continuing on till I arrived near the lower margin, the south pole was again attracted. This is invariably the case in whatever position in regard to the horizon the polished surface is placed, and however suddenly this position is changed. I found this to be the case with all iron. Whether this fact is known to those who have made magnetism an object of peculiar investigation, I cannot say. It is very possible that it must be attributed to the general magnetism of the globe.

ART. IX.—*On the Allotropism of Chlorine as connected with the Theory of Substitutions;* by JOHN WILLIAM DRAPER, M. D., Professor of Chemistry in the University of New York.*

THE researches of M. Dumas on chemical types have shown that between chlorine and hydrogen remarkable relations exist, indicating that the electrical characters of elementary atoms are not essential but rather incidental properties. The extension of these researches has given much weight to the opinion that the electro-chemical theory may be regarded as failing to account for the replacement of such bodies as hydrogen by chlorine, bromine, oxygen, &c. I do not know that as yet any direct evidence has been offered that the electrical character of an atom is not an essential quality, but one that changes with circumstances. It appears to be rather a matter of inference than of absolute demonstration.

It is the object of this memoir to furnish such direct evidence, and to show that chlorine, the substance which has given rise to

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* Communicated by the author.

the discussions connected with the theory of substitutions, under the very circumstances contemplated, has its electro-chemical relations changed.

More than two years ago I brought before the British Association some of the facts. They were subsequently published in the Philosophical Magazine in a memoir on "Tithonized Chlorine."* The connexion of these experiments with the discussion between the theory of substitutions and the electro-chemical theory is obvious.

Very recently M. Berzelius has published an important paper on the allotropism of simple bodies, the object of which is to point out that many of those bodies can assume different qualities by being subjected to certain modes of treatment. Thus carbon furnishes three forms—charcoal, plumbago, and diamond.

To a certain extent these views coincide with those which have offered themselves to me from the study of the properties of chlorine. They are not however altogether the same. M. Berzelius infers that elementary bodies can, as has been said, assume under varying circumstances different qualities. The idea which it is attempted to communicate in this memoir is simply this,—that a given substance, such as chlorine, can pass from a state of high activity, in which it possesses all its well known properties, to a state of complete inactivity, in which even its most energetic affinities disappear. And, that between these extremes there are innumerable intermediate points. Between the two views there is therefore this essential difference,—from the former, it does not appear what the nature of the newly assumed properties may be; from the latter, they must obviously be of the same character, and differ only in intensity or degree—diminishing from stage to stage until complete inactivity results.

In the case of chlorine the same activity which is communicated by the indigo rays can also be communicated by a high temperature, or by the action of platina. The term "tithonized chlorine," which I formerly used, is therefore too restricted, and, indeed, in this view of the case improper. The simple appellations—active and passive, are perhaps the best, and I shall therefore employ them.

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* London, Edinburgh, and Dublin Philosophical Mag., July, 1844.

The points which this memoir is intended to establish are,—

I. That chlorine gas can exist under two forms. In the same way that metallic iron can exist as active or passive iron, chlorine can assume the active or passive state.

II. Having established the fact of the allotropism of chlorine, I shall then show its connexion with the theory of substitutions of M. Dumas, and how the most remarkable points in that theory may be easily accounted for.

The time, perhaps, has not yet arrived for offering a complete mechanical explanation of the assumption of an active or passive state. It may be remarked, that a very trivial modification of our admitted views of the relation between atoms and their properties, is all that is required to give a consistent explanation of every one of these facts. Instead of regarding the specific qualities of an atom as appertaining equally to the whole of it in the aggregate, we have merely to assume that there is a relation between its properties and its sides, and that any force which can make it change its position upon its own axis will throw it into the active or passive state. But this is nothing more than the well known idea of the polarity of atoms.

Phenomena of the Decomposition of Water by Chlorine in the Rays of the Sun.

From the various facts which might be employed as offering the means of establishing the allotropism of chlorine, I shall select those which arise from an examination of the phenomena of the decomposition of an aqueous solution of chlorine by the rays of the sun.

For many years it has been known that an aqueous solution of chlorine undergoes decomposition by the aid of the solar rays. Several of the most remarkable phenomena connected with this decomposition appear to have been overlooked. Among such may be mentioned the singular fact, that chlorine which has been thus influenced by the sun has obtained the quality of effecting this decomposition subsequently, to a measured extent, even in the dark. Not to anticipate what I have to offer on this point, I shall now proceed in the first place to establish the various facts connected with the decomposition in question.

Having provided a number of small glass vessels, consisting of a bulb and neck of the capacity of from 1·5 to 2·0 cubic inches, I filled them with a solution of chlorine in recently boiled water, and inverted them in small glass bottles containing the same solution, as shown in fig. 1. With these bulbs the following experiments were made.

I. An aqueous solution of chlorine does not decompose in the dark.

One of the bulbs was shut up in a dark closet, and kept there for a week,—being examined from time to time. No decomposition was perceptible, for no gas collected in the upper part of the bulb.

II. An aqueous solution of chlorine decomposes in the light.

One of the bulbs was placed in a beam of the sun reflected into the room by a heliostat. For sixteen minutes no change was perceptible; then small bubbles of gas made their appearance; they increased in quantity for a time, but finally the speed of decomposition became uniform. On analysis by explosion with hydrogen, after washing out any chlorine contained in it, this gas was found to contain 97 per cent. of oxygen.

III. The rapidity of this decomposition depends on the quantity of the rays, and on the temperature.

In various repetitions of these experiments, on different days, I soon convinced myself that the rate of evolution of the oxygen depended on the quantity of the rays. Among other proofs I may mention this:—After ascertaining the rate of decomposition in the reflected beam, if the bulb be set in the direct sunshine, the bubbles increase in number; the total quantity of oxygen evolved becoming greater in the same space of time, an effect obviously due to the difference of intensity of the reflected and incident beams. When a certain point is gained, apparently no further increase of effect takes place on increasing the brilliancy of the light, as I found by employing a convex lens.

With respect to the influence of temperature. If while one of the bulbs is actively evolving gas in the sun-rays, it be warmed by the application of a spirit lamp, the amount of gas thrown off becomes very much greater. A difference of a few degrees produces a striking effect. As an illustration of this, I placed in the sunshine two bulbs which were nearly alike, except that one of them was painted black with India ink on that portion which was farthest from the sun. The rays coming through the transparent part had access to the solution, and then impinging on the dark side raised its temperature. On measuring the quantity of gas collected, it was found,

In the transparent bulb, - - -	3·46
In the half blackened bulb, - - -	6·19

IV. The decomposition of water, once begun in the sunbeams, goes on afterwards in the dark.

1st. This very important fact may be established in a variety of ways. Thus, if a bulb be removed from the sunshine whilst it is actively evolving gas, and be placed in the dark after all the gas has been turned out of it, a slow evolution continuously goes on; the gas collecting in the upper part of the bulb.

2d. A bulb A, Fig. 2, having a neck *b*, the end of which was bent at *c* upwards at an angle of about 45 degrees, was employed. After exposure to the sun, by inverting the bulb and with one finger closing the extremity *c*, the gas disengaged could be transferred to a graduated vessel and measured. I satisfied myself by several variations of this arrangement that the small quantity of water, introduced from time to time when the gas bubble escaped from the end of the tube *e*, exerted no essential influence on the phenomenon. The following table shows the amount of gas evolved in the dark during the periods indicated.

The bulb having been exposed to the sunshine, in ten minutes the evolution of gas commenced, and in an hour, ·107 cubic inch having collected, this was thrown away, and the arrangement placed in the dark. To prevent the undue escape of the chlorine, the flat piece of glass *d*, was laid on the open end of the tube *c*. In each successive hour the quantity of gas given in the following table was then evolved.

First hour, - - - -	·0162
Second " - - - -	·0159
Third " - - - -	·0086
Fourth " - - - -	·0060
Fifth " - - - -	·0038
Sixth " - - - -	·0031

And for four days afterwards gas was collecting in the bulb in diminished quantities.

V. This evolution of gas in the dark is not merely a gradual escape of oxygen, originally formed whilst the solution was exposed to the sun, but is traceable to an influence continuously exerted by the chlorine, arising in properties it has acquired during its exposure to the rays.

If a bulb which has been exposed to the sun be raised by a spirit lamp to such a temperature that its gaseous constituents are rapidly evolved, its extremity dipping beneath some of the solution in the bottle, after allowing a sufficient space of time for the disengaged chlorine to be re-dissolved, and the oxygen be turned out of the bulb, it will be found on keeping the arrangement in the dark, that oxygen will slowly disengage as before.

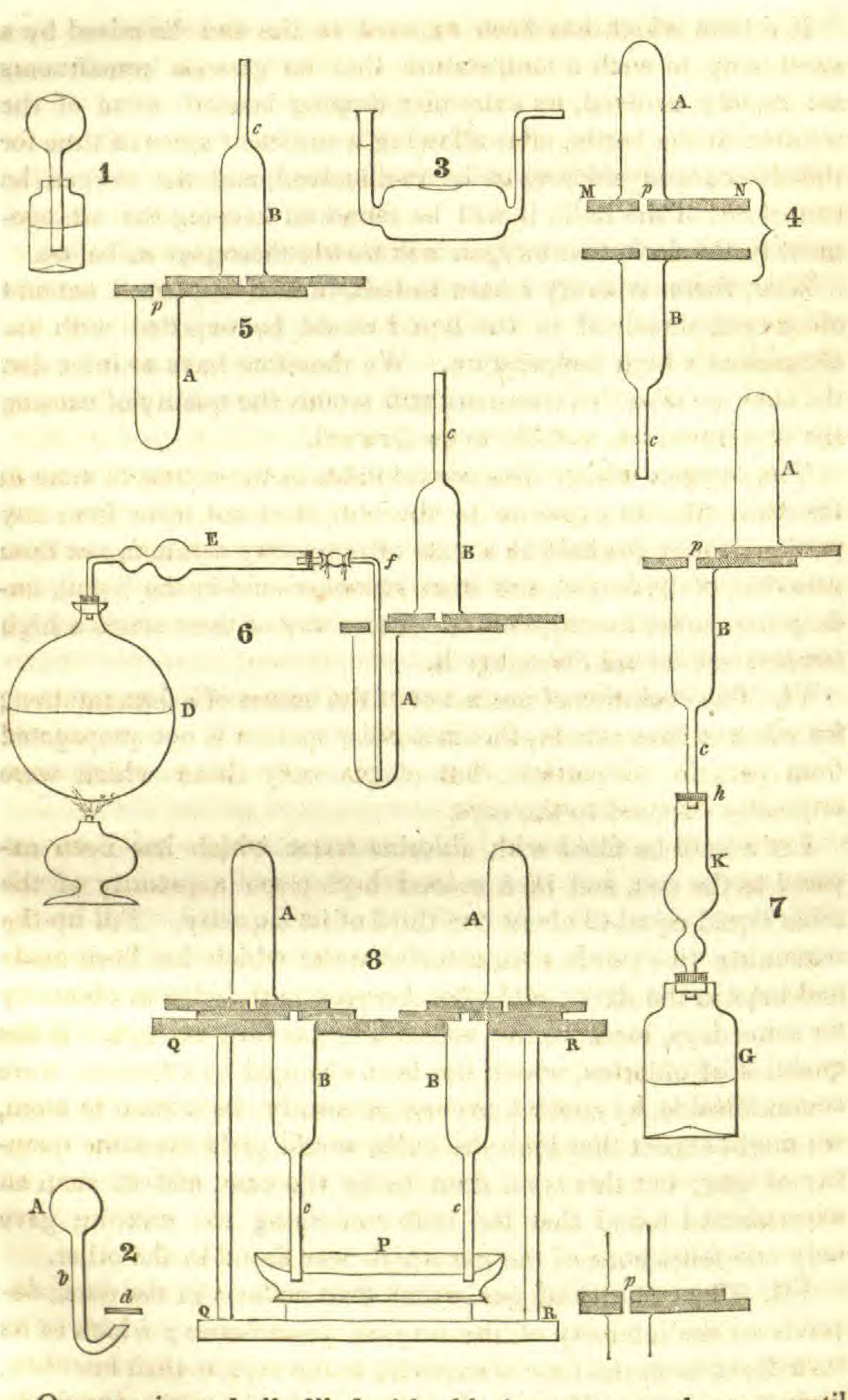
Now, there is every reason to believe that any small amount of oxygen dissolved in the liquid would be expelled with the chlorine at a high temperature. We therefore have to infer that the chlorine after this treatment still retains the quality of causing the decomposition steadily to go forward.

The oxygen which thus accumulates in the course of time in the dark, after an exposure to the sun, does not arise from any portion of that gas held in a state of temporary solution, nor from peroxide of hydrogen, nor from chlorous acid in the liquid, undergoing partial decomposition. From any of these states a high temperature would disengage it.

VI. The evolution of gas is not of the nature of a fermentation; for when it once sets in, the molecular motion is not propagated from particle to particle, but affects only those which were originally exposed to the rays.

Let a bulb be filled with chlorine water which has been exposed to the sun, and in a second bulb place a quantity of the same liquid equal to about one third of its capacity. Fill up the remaining two thirds with chlorine water which has been made and kept in the dark; and after keeping both bulbs in obscurity for some days, measure the volumes of gas they contain. If the qualities of chlorine, which has been changed by exposure, were communicable, by contact or close proximity, from atom to atom, we might expect that both the bulbs would yield the same quantity of gas; but this is far from being the case, and in such an experiment I found that the bulb containing the mixture gave only one fourteenth of the gas which was found in the other.

VII. The quantity of gas which thus collects in the dark, depends on the intensity of the original disturbance; which in its turn depends on the time of exposure to the rays, to their intensity, and other such conditions. In other words, the rays are perfectly definite in their action,—a long exposure giving a larger amount of subsequent decomposition, and a short exposure a less amount.



On exposing a bulb filled with chlorine water to the rays until bubbles of gas began to appear, and a second one until the decomposition had been actively going on for a quarter of an hour, and then transferring both to the dark, and measuring the oxygen which collected at the end of a day, I found in the former one twelfth of what was collected in the latter.

VIII. In a given quantity of chlorine water, the decomposition in the dark corresponding to a given exposure to the light having been performed, and the proper quantity of oxygen evolved, and the phenomenon ended, it can be reëstablished from time to time, as long as any chlorine is found in the liquid, by a renewed exposure to the sun.

In a glass vessel like Fig. 3, which, indeed, was nothing more than one of Liebig's drying apparatus, I placed a sufficient quantity of chlorine water to fill the larger vessel, and also the vertical tubes half full. After exposing this to the light for a certain time, until decomposition had fairly set in, I placed it in the dark, and found that for several days it gave off gas,—the quantity continually diminishing. Finally, no more gas was evolved. But the liquid still contained free chlorine, as was shown by its color. I therefore again exposed it to the sun, and repeating the former observation, found that it evolved gas for several days in the dark. A third exposure was followed by the same result.

The form of this vessel renders it very convenient for these experiments; because when sufficient gas has collected for the purpose of observation, it is easily removed by inclining the instrument, without the necessity of introducing fresh quantities of liquid.

Having found, as has been said, that the rapidity of the decomposition depended to a certain extent on the temperature, it seemed desirable to determine whether heat alone could bring about the change.

IX. The decomposition of water by chlorine is not brought about by mere elevation of temperature when the liquid is set in the sunbeam,—although heat accelerates, it does not give rise to the phenomenon.

1st. I raised by a spirit lamp the temperature of one of the bulbs nearly to its boiling point, until so much gas was given off that all the liquid was expelled from the tube to the bottle beneath. If at this temperature, which probably was higher than 200° Fahr., chlorine had been able to decompose water, an equivalent quantity of oxygen would have been produced; but on allowing the apparatus to cool, all the gas was re-absorbed, with the exception of a small bubble, amounting in volume to $\frac{1}{1087}$ of the water. This bubble, which was left after the chlorine was re-condensed, I found in three different experiments contained 32, 33, and 36 per cent. of oxygen,—the remainder being nitrogen; but this being nearly the constitution of the gas which is dissolved in ordinary water, the source from which the small bubble came was inferred to be the water used in these experiments.

2d. One of the bulbs was painted black all over with India ink. Its temperature now rose much higher than in former experiments when it was set in the sun, but not a bubble of oxygen appeared.

X. When chlorine water has been exposed to the sun, the oxygen accumulated in it is readily expelled by raising the temperature.

Having exposed one of the bulbs used in the last experiment, until it was actively evolving gas, I raised its temperature with the spirit lamp until the bulb was full of gas. But, on cooling, this gas did not all condense as in the last instance, a large quantity remained behind. This was oxygen.

These ninth and tenth facts are of further interest, as bearing upon a question which has been much discussed by chemists,—the nature of the bleaching compounds of chlorine. The chloride of lime, and other such substances, probably have the same theoretical constitution as chlorine water. Berzelius and Balard suppose, that in this solution chlorous or hypochlorous acids exist. It might be inquired, if this be the condition of things, why does not an exposure to heat alone evolve oxygen, for chlorous acid is exceedingly liable to decomposition by slight elevation of temperature, and we should be justified in inferring that if any of this acid is to be found in chlorine water, it would be decomposed at the boiling point. M. Millon adopts the view that the bleaching compounds are metallic chlorides analogous to the corresponding peroxides. But the ninth fact seems incompatible with this view. If chlorine water be analogous to peroxides of hydrogen, and this last be what its name imports, and not merely oxygenated water, it is difficult to understand why when chlorine water is thus boiled oxygen is not given off. If the atom of chlorine and the atom of oxygen in this body are placed under the same relations to the atom of hydrogen, it seems necessary that the chlorine atom at 212° Fahr. should expel the oxygen atom, and chlorohydric acid form. It is probable, indeed, that the two oxygen atoms in peroxide of hydrogen are related to their hydrogen atoms with different degrees of affinity, and that one of them is retained far more loosely than the other. But this would correspond with our ideas of oxygenized water and not peroxide of hydrogen, and leads us to the conclusion that the solution employed in this memoir is strictly a solution of chlorine in water.

XI. The decomposition of chlorine water, when placed in the sunbeam, does not begin at once, but a certain space of time intervenes, during which the chlorine is undergoing its specific change.

I need quote no further instance of the truth of this than the experiment given in support of the second fact. This is the same phenomenon which takes place when chlorine and hydrogen are exposed together; they do not begin to unite at once, but a certain space of time elapses, during which the preliminary tithonization is taking place; and when that is over union begins.*

On the Relations of Chlorine and Hydrogen.

We have thus traced the cause of the decomposition of water, in the case before us, to a change impressed upon the chlorine by exposure to the rays of the sun. In this decomposition three elementary bodies are involved—chlorine, oxygen, and hydrogen.

We can therefore reduce the problem under discussion to simple conditions, and study the relations of each of these substances to each other and to the solar rays successively.

When a mixture of oxygen and hydrogen gases, in the proportion to form water, is exposed to the most brilliant radiation converged upon it by convex lenses, union does not ensue; the reason being, as I have formerly shown, that those gases are perfectly transparent to the rays, and do not possess either real or ideal coloration. For the same cause, water exposed alone for any length of time to the sun, or to the influence of a large convex lens, does not decompose. It is transparent, and cannot absorb any of the rays.

But, as is well known, a mixture of chlorine and hydrogen unites, under the same circumstances, with an explosion. I have formerly proved that this depends on the absorption of the indigo rays. For in the indigo space the action goes on with the greatest activity.

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* Philosophical Magazine, July, 1844.

If, therefore, this phenomenon is due to absorption taking place by the mixture, it is easy to determine the function discharged by each of its ingredients.

I transmitted a ray of light through hydrogen gas, contained in a tube seven inches long, the ends of which were terminated by pieces of flat glass; and then dispersing the ray by a flint glass prism, received the resulting spectrum on a daguerreotype plate. Simultaneously, by the side of it, I received the spectrum of a ray which had not gone through hydrogen, but through a similar tube filled with atmospheric air. On comparing the impressions together, I could find no difference between them.

I therefore infer that hydrogen gas does not exert any absorptive action on the solar rays.

In one of the foregoing tubes I placed dry chlorine gas, the other containing atmospheric air as before, and receiving the two spectra side by side on the same daguerreotype plate, I found that a powerful absorption had been exercised by the chlorine. All the tithonic rays between the fixed line H and the violet termination of the spectrum were removed, and no impression corresponding to their place was left upon the plate. On repeating this experiment so as to determine with precision the rays which had been absorbed, I found that chlorine absorbs all the rays of the spectrum included between the fixed line *i* and the violet termination, and is probably affected by all those waves whose lengths are between 0·00001587 and 0·00001287 of a Paris inch; and inasmuch as it absorbs photic rays included between the same limits, it is to this absorption that its yellow color is due.

In the Philosophical Magazine the same result was established by me in another way. I found that a ray which had passed through a given thickness of a mixture of equal volumes of chlorine and hydrogen, lost by absorption just half as much of its original intensity as when it passed through the same thickness of pure chlorine gas; a result which obviously leads to the conclusion that when chlorine and hydrogen unite, under the influence of the sun, they discharge functions which are different—the chlorine an active and the hydrogen a passive function. The primary action or disturbance takes place upon the chlorine, and a disposition is communicated to it enabling it to unite readily with the hydrogen.

By arranging a series of tubes containing a mixture of these gases in the spectrum, it was found that the gases situated in the indigo space went into union first.

These various experiments enabling us thus to trace to the chlorine the source of disturbance, I have next to remark, that chlorine which has been exposed to the rays of the sun has gained thereby a tendency to unite with hydrogen which is not possessed by chlorine which has been made and kept in the dark. In proof of this fact, I may cite an experiment from the Philosophical Magazine for July, 1844.

"In two similar white glass tubes place equal volumes of chlorine which has been made from peroxide of manganese and muriatic acid by lamplight, and carefully screened from access of daylight. Expose one of the tubes to the full sunbeams for some minutes, or if the light be feeble, for a quarter of an hour. The chlorine which is in it becomes tithonized. Keep the other tube during this time carefully in a dark place; and now, by lamplight, add to both equal volumes of hydrogen gas. These processes are best carried on in a small porcelain or earthenware trough, filled with a saturated solution of common salt, which dissolves chlorine slowly, and to avoid explosions, operate on limited quantities of the gases. Tubes that are eight inches long and half an inch in diameter will answer very well."

"The tubes now contain the same gaseous mixture, and differ only in the circumstance that one is tithonized and the other not. Place them therefore side by side before a window, through which the entrance of daylight can be regulated by opening the shutter; and now, if this part of the process is conducted properly, it will be seen that the tithonized chlorine commences to unite with the hydrogen, and the salt water rises in that tube. But the untithonized chlorine shows no disposition to unite with its hydrogen, and the liquid in its tube remains motionless for a long time. Finally, as it becomes slowly tithonized by the action of daylight impinging on it, union at last takes place. From this therefore we perceive that chlorine which has been exposed to the sun will unite promptly and energetically with hydrogen, but chlorine which has been made and kept in the dark shows no such property."

This form of experiment may be supposed imperfect, since the chlorine is in a moist condition and confined by water. I have therefore made the following variation.

I took a tube A, (Fig. 4,) six inches long and half an inch in diameter, closed at one end and open at the other, and cemented its open end on a piece of flat plate glass M, N, one inch wide and two long, ground on both sides, and having a hole *p* one sixth of an inch in diameter perforated through it. This hole was not in the centre of the glass, but on one side, as shown in the figure. The interior of the tube was perfectly clean and dry.

A second tube B, consisting, as shown in Fig. 4, of two portions; a wide portion B, and a narrower tube *c*, was cemented on another piece of ground plate glass, similar to the foregoing in all respects. The tube *c* was open at its lower extremity; and the entire capacity of B and *c* conjointly was adjusted so as to be equal to the capacity of A.

Next I filled A with dry chlorine, and B*c* with dry hydrogen; and kept them from mixing until the proper time, by operating in the following way: I placed the ground glasses face to face, as shown in Fig. 5, with a small quantity of soft tallow between them, arranging them in such a way that the aperture which led to the interior of A was open.

Through this aperture dry chlorine was conveyed. It was generated by a mixture of peroxide of manganese and chlorohydric acid in the flask D, (Fig. 6,) and passed along a tube E, filled with chloride of calcium. A slender glass tube *f*, conveyed it to the bottom of A, which was then filled by displacing the atmospheric air. When A was supposed to be full of chlorine it was slowly lowered so as to bring the tube out of the aperture, and as soon as it was disengaged the glass plates were moved in such a manner by sliding them on one another, that the aperture leading into A was shut; but that leading into B was open. The vessel A was thus filled with dry chlorine and securely closed.

In the next place I filled B with dry hydrogen, which was done as follows. To a bottle G, (Fig. 7,) containing dilute sulphuric acid and zinc, a drying tube K, of chloride of calcium was adjusted, and at its upper end a cork *h*, arranged so as to receive tightly the tube *c*. In a short time, therefore, B became full of dry hydrogen, the surplus escaping through the open aperture *p*. The two ground glass plates were now moved on one another in such a manner that they mutually closed one another. The vessel A was therefore filled with dry chlorine, and the vessel B*c* with an equal volume of dry hydrogen, without communicating for the present with one another.

I had provided two sets of these tubes as nearly alike as they could be made, and operated with them in the following manner.

In a dark room I filled the tube A of each of them with dry chlorine in the manner just described, and confined it by sliding the plates. One of the tubes was retained in the dark room and kept carefully screened from the light, but the other was set for half an hour in the sunbeams. The chlorine which was in it underwent the specific change which it is the object of this paper to describe.

After restoring this tube to the dark room, and waiting a few minutes for it to gain the same temperature as the other, the tubes B*c* of each set were filled with dry hydrogen in the manner described. In each instance, as soon as the plates were moved on each other so as to confine the hydrogen, and they were released from the cork *h* of the drying tube K, (Fig. 7,) their lower extremity was dipped beneath the surface of some water contained in a saucer P, (Fig. 8.) The two sets of tubes being held steadily in a proper position by the aid of a wooden frame Q R. The two sets of tubes now differed from one another in nothing but the circumstance that the chlorine of one had been exposed to the sun, and that of the other had not.

The gases were now brought in contact. This was easily done by sliding each pair of ground glasses until their apertures coincided, as shown in Fig. 9. The hydrogen now rose through the hole into the upper vessel, the chlorine descending through it, mutual and perfect diffusion of the two gases rapidly taking place. This was done by lamplight in the dark room. And now it could be ascertained that the gases were at the same temperature in the different tubes, and that the experiment had thus far been carried on successfully by the water retaining its level at the same point in the tubes *c* of both sets. If that which had been in the sunshine was warmer than the other, as soon as the apertures coincided, a bubble of gas would have escaped through the water, or at all events the level would have changed.

It remained now to open the shutter of the dark room, the tubes having been previously set in such a position that the light would fall equally on both. As soon as this was done, the chlorine which had been exposed to the sun united at once with its hydrogen, and the water rose in the tube *c*. But in the other, which had not been exposed to the sun, no movement took place, until the gases had had time to be affected by the light coming through the open shutter.

When care has been taken to have the gases made quite dry, and owing to the narrowness of the tube *c*, no aqueous vapor has had time to contaminate the gas in B, so that no water is present to condense the chlorohydric acid as it forms; a little delay may be occasioned in the liquid rising in the tube, the chlorine of which was exposed to the sun. But, after a time, a mist arises in the neighborhood of the water in the narrow tube, due to the chlorohydric acid condensing, and then the process goes forward with regularity.

It appears, therefore, that chlorine by exposure to the sun contracts a tendency to unite with hydrogen which is not possessed by chlorine which has been kept in the dark.

On the Allotropism of Chlorine, or its passive and active states.

In what then does this remarkable change impressed by indigo rays upon chlorine consist? This is the question which immediately arises from the phenomena we have had under consideration.

To this I answer, that when chlorine has been thus influenced its electro-negative properties are exalted, and it has passed from an inactive to an active state.

It is now fully established that a great number of the elementary bodies undergo similar modifications. Many of them can exist in no less than three different states, and these peculiarities are impressed on the compounds to which they give rise. To these peculiarities Berzelius has recently directed the attention of chemical philosophers in his paper "On the allotropism of simple bodies, and its relation with certain cases of isomerism in their combinations." He shows that of the elementary bodies now known, many undoubtedly exist in several allotropic states, and infers that all are liable to analogous modifications. He indicates that the isomerism of compound bodies is due, sometimes to the different modes in which the atoms of which their constituent molecules consist are grouped, and sometimes to the different allotropic states in which one or the other of those elements is found. Thus as M. Millon has remarked, the intrinsic difference between carburetted hydrogen gas (CH), and otto of roses (CH), which are isomeric bodies, may perhaps consist in this, that in the former the carbon is under the form of common charcoal, and in the latter under the form of diamond.

The following instances from Berzelius may serve as examples of these allotropic states.

Carbon is known under three forms—charcoal, plumbago, and diamond. They differ in specific gravity, in specific heat, and in their conducting power as respects caloric and electricity. In their relations to light, the one perfectly absorbs it, the second reflects it like a metal, the third transmits it like glass. In their relations with oxygen, they also differ surprisingly; there are varieties of charcoal that spontaneously take fire in the air, but the diamond can only be burnt with difficulty at a high temperature in pure oxygen gas. The second and third varieties do not belong to the same crystalline form.

Silicium exists also under two forms. In its first it burns with facility in the air under a slight elevation of temperature. But, if it be previously exposed to a strong red heat, it changes into the second variety and becomes incombustible, so that it will not oxydize when placed with nitrate of potash in the hottest part of a blowpipe frame. As is well known, there are two forms of silicic acid; one soluble in water and hydrochloric acid, but passing into the insoluble state by being previously made red hot. The silicium therefore carries in its combination the same properties that it exhibits in the free state.

In the same manner it might be shown that sulphur, selenium, phosphorus, titanium, chromium, uranium, tin, iridium, osmium, copper, nickel, cobalt, and a variety of other bodies exist under several different forms, with distinctive properties that are often well marked. In several of them the influence of this allotropic condition is plainly carried into the compounds, as is well shown in the two varieties of arsenic which give rise to the two arsenious acids.

The passage from one allotropic state to another takes place commonly through the agency of apparently very trivial causes, such as a slight elevation of temperature and the contact of certain bodies. Thus iron, which is so easily oxydized under ordinary circumstances, appears to lose its affinity for oxygen after it has been touched under the surface of nitric acid by a piece of platina. It then puts on the attributes of a noble metal, and simulates the properties of platina and gold.

This remarkable instance of the passage from an active to a passive state, as Berzelius remarks, may lead to a conjecture respecting the true condition of certain gases. No one can reflect on the inactivity of nitrogen gas under ordinary circumstances, contrasted with its equally extraordinary activity as a constituent of organic bodies, without being struck with the apparent connexion of that phenomenon with these of allotropism. And though Berzelius with his customary caution merely insinuates that nitrogen can exist under two forms; the facts which are here developed in relation to chlorine appear to show that that opinion rests on something more solid than conjecture. The habitudes of many of the gaseous bodies strengthen this conclusion. Oxygen gas refuses to unite when mixed with hydrogen precisely in the manner of chlorine, and it requires a certain modification to be made in the electro-negative element before water or hydrochloric acid can result.

Just therefore in the same manner that so many elementary bodies can put on under the influence of external causes an active or passive condition, I infer, as the final result of the experiments brought forward in this memoir, that chlorine is one of these allotropic bodies, having a double form of existence. That, as commonly prepared, it is in its passive state; but that on exposure to the indigo rays, or other causes, it changes and assumes the active form. That, in this latter state, its affinity for hydrogen becomes so great that it decomposes water without difficulty, as in the experiment which this memoir is designed to illustrate.

On the relation of the preceding conclusions with the theory of substitutions.

Having thus explained the facts which appear to indicate the allotropism of chlorine, I shall now offer some considerations on its connection with the theory of substitutions of M. Dumas.

Admitting the fact that the electro-negative qualities of chlorine are exalted upon its exposure to the indigo rays, and that the resulting effect is not a temporary thing, but one which lasts for a considerable period of time, as appears to be proved in the Philosophical Magazine, (July, 1844,) we can give a very plain and simple account of the decomposition of water by this gaseous substance under the influence of sunshine.

Upon the same principle that a mixture of chlorine and hydrogen may be kept in the dark without union for a long time, so may a solution of chlorine in water be preserved. The chlorine is in an inactive state.

But, if any thing is done to make the chlorine take on its other form and pass to the active condition; if it be, for example, set in the sunshine, its affinity for hydrogen is exhibited, and decomposition is the result.

The qualities thus communicated to the chlorine not being of a transient kind, but remaining for a length of time, we see how it is that after an exposure to the sun decomposition is subsequently carried forward in the dark.

The indisposition of chlorine to unite with carbon, which has been regarded as a singular quality, is not more remarkable than its indisposition to unite with hydrogen in the dark.

If the power which chlorine assumes of uniting with hydrogen and carbon depends on a change in its electrical relations,—a passage from the passive to the active state,—we might expect that those various causes which in the case of other elementary bodies bring about analogous changes, and throw them from one allotropic condition to another, would here also exercise a perceptible action. Among such causes we may enumerate the action of a high temperature, and the contact or presence of other bodies.

It may be remarked in the instances to which Berzelius has referred, that exposure to a high temperature is one of the most frequent causes of allotropic change. In the case of chlorine the remark holds good, for, as is well known, when a mixture of chlorine and hydrogen is passed through a red-hot tube, chlorohydric acid forms with rapidity. The high temperature, therefore, impresses upon chlorine the same tendency to unite with hydrogen which is communicated by the solar rays.

But the contact of other bodies frequently determines in a given substance an allotropic change. Thus, when a piece of iron is placed in nitric acid in contact with platina, the iron becomes less electro-positive, or what is the same thing, more electro-negative than it was before, and the acid can no longer oxydize it. The contact of the very same substance, platina, determines an analogous change in chlorine,—giving it at once the capacity of uniting with hydrogen. The porous condition of spongy platina is not essential to the result, for clean platina foil exhibits the same phenomenon.

In the case of iron, the action of a high temperature or the contact of platina, throws the metal from the active to the passive state; in the case of chlorine the same causes apparently produce the opposite result, throwing the gas from the passive to the active state. But the difference is rather in appearance than in reality. In both cases it amounts to the same thing, and is an exaltation of the electro-negative qualities of either substance respectively.

The same causes, therefore, which produce allotropic changes in other bodies, produce analogous changes in chlorine.

Now, among the physical facts connected with the theory of types and substitutions, two are prominent; 1st. The union of chlorine with hydrogen, giving rise to the removal of that hydrogen as chlorohydric acid. 2d. The subsequent function discharged by the chlorine, which has entered as an integrant portion of the molecules, and occupies the place of the hydrogen removed. This function is in many instances that of the hydrogen itself, and it is this fact which is the remarkable point in the phenomena of substitution,—that an intensely electro-negative body can act the part of a positive body. It is this fact which is leading chemists to the conclusion that the properties of compound bodies arise as much from the mode of grouping of their constituent atoms as from the qualities of those atoms themselves.

But, if it be admitted that the experiments related in this memoir establish the allotropism of chlorine, then it is plain that a very different and perhaps satisfactory account of the phenomena of substitution may be given.

As has been already said, no difficulty can arise in accounting for the removal of hydrogen from organic bodies, or for the first fact just alluded to. This removal will ensue whenever processes are resorted to which bring the chlorine into an active state. When we expose acetic acid and chlorine to the sun, the latter becomes active, gains the quality of uniting with hydrogen, and chloroacetic acid forms. Probably the same change could be brought about by the aid of spongy platina and heat.

Upon the second fact,—the similarity of function discharged by the chlorine which has replaced the hydrogen atoms with the function of those atoms themselves,—a flood of light is thrown by other phenomena of allotropism. If a piece of iron be dipped in hydrated nitric acid, though it may be acted on for a few moments, it rapidly becomes passive. And so with the chlorine atoms which have substituted the hydrogen. In the circumstances in which they are placed they rapidly revert from the active to the passive state. They are no longer endued with an intense electro-negative quality,—they have assumed the condition of inactivity. The fact that chlorine in chloracetic acid simulates the functions of hydrogen in acetic acid, is not more remarkable than that iron touched by platina under nitric acid simulates the properties of that noble metal.

Do not, therefore, these circumstances seem to point out, that if we admit the fact that simple substances can exist in different states, in a passive and an active form, the phenomena of substitution are deprived of much of their singularity.

Thus, to recall once more the example to which I have before referred, and which has been so well illustrated by the researches of M. Dumas, the transmutation of acetic into chloracetic acid exhibits a double phenomenon. 1st. The existence of active chlorine, expressed by the removal of hydrogen, activity having been communicated by the rays of the sun, or by some other appropriate method. 2d. The existence of passive chlorine in the particles of chloracetic acid.

I consider that were no other instances known, the two cases cited by Berzelius of the double forms of silicic acid and arsenious acid establish the fact, that a given allotropic condition may be continued by an elementary atom when it goes into union with other bodies. And I regard the various cases in which hydrogen is replaced by iodine, bromine, &c., in which, in the resulting compound, those energetic electro-negative elements fail to give any expression of their presence and activity, as analogous to other common and too much overlooked facts. Chlorine which is in the dark, may be kept in contact with hydrogen without exhibiting any of its latent energies. Touched by an indigo ray, it instantly assumes the active state, and a violent explosion is the result.

To use, therefore, the same nomenclature to which Berzelius has resorted in the case of other allotropisms, we may designate the ordinary form of chlorine, made by the action of chlorohydric acid on peroxide of manganese, as $Cl\beta$; and admit that this passes into the condition $Cl\alpha$, by the action of the solar rays, contact of platina, or a high temperature. And that in any case of substitution the hydrogen is removed under the condition $Cl\alpha$, and the resulting compound contains $Cl\beta$; the assumption of the passive state disguising the presence of the electro-negative atom.

The explanation here given of the phenomena of substitutions involves the position that chlorine when brought in relation with carbon under certain circumstances is thrown into the passive state, the state $Cl\beta$. We naturally look for direct evidence that this is the case. It seems to me that there are many well known chemical facts which tend to establish the passive condition. In the first case to which we turn, the chlorides of carbon, the inactive state is established in a striking manner. The affinity which exists between chlorine and carbon is apparently feeble; yet when these bodies have once united, the chlorine is brought into such a condition that it has lost the quality of being detected by the ordinary tests which determine its presence. How strongly does this contrast with the case of chlorohydric acid; a feeble affinity unites carbon and chlorine; an intense affinity unites hydrogen and chlorine; yet in the former case the chlorine is undiscoverable by the commonest tests, in the latter it yields to them all. And the causes are obvious,—in the one case it is in the passive, in the other in the active condition.

I have hitherto spoken of the active and passive states as though they were fixed points in elementary bodies, and as though the transition from one to the other was abrupt and sudden. I have done this that the views here offered might be unembarrassed and distinct. But there are many facts which serve to show that the passage from a state of complete activity to a state of complete inactivity takes place through gradual steps. Thus, in carbon itself, there are undoubtedly many intermediate stages between the almost spontaneously inflammable varieties and diamond, which, under common circumstances, is incombustible. Berzelius admits three allotropic conditions of this body, $C\alpha$, $C\beta$, $C\gamma$. Between the first and last terms of this series it is probable that several intermediate bodies besides plumbago might be found;

their existence establishing the gradual passage from one to the other state.

For similar reasons, in this memoir, the illustrations and arguments given have for the most part been restricted to one substance, chlorine. It need scarcely be pointed out, in conclusion, that if the views here offered are true, very much of this reasoning may be transferred to other bodies, as oxygen, nitrogen, hydrogen, sulphur, &c. When oxygen and hydrogen are mixed, there is no disposition exhibited by them to unite, and this does not arise from their happening to have the gaseous form. As in the instance we have been considering, if they are exposed to a high temperature, or to the influence of platina, the active condition is assumed with promptitude, and union takes place.

The power which carbon possesses of throwing bodies into a completely passive state is far from being limited to chlorine. It re-appears in the case of sulphur. The sulphuret of carbon yields to none of the tests to which we commonly resort for determining the presence of sulphur, for the simple reason that its sulphur is in an inactive state. This substance, moreover, serves to illustrate what has been said of the gradual passage of bodies from a state of complete activity to one of complete inactivity. Berzelius recognizes for it three different allotropic states; an alpha, beta, and gamma condition. In none of these is it in that condition of absolute inactivity which it assumes in the sulphuret of carbon.*

In offering these experiments and arguments to the consideration of chemists, I am fully aware of the magnitude of the change which would be impressed on the science generally, and especially on several of our modern theories, by their reception. The long established idea of the immutability of the properties of elementary bodies would, to a certain extent, be sacrificed; and it is probable that before these results are conceded, more cogent evidence of the main principle will be required. In the mean time, however, it is plain that the admission of these doctrines throws much light on theories now extensively attracting the attention of men of science, and for that reason they commend

* For these examples,—the chloride and sulphuret of carbon, I am indebted to M. Millon's paper, "Remarks on the elements which compose organic substances, and on their mode of combination." Comptes Rendus, T. XIX, p. 799. That chemist, however, gives a very different explanation of the phenomena involved.

themselves to our consideration. I have offered no opinion here on the atomic mechanism which is involved in these changes from an active to a passive state, though it is impossible to deal with these things without the reflection arising in our minds, that here we are on the brink of an extensive system of evidence connected with the polarity of atoms,—an idea which, under a variety of forms, is now occurring in every department of natural philosophy.

University of New York, July 29, 1845.

Art. X.—*Bibliographical Notices.*

1. *Travels in North America in the Years* 1841–42, *with Geological Observations on the United States, Canada, and Nova Scotia;* by Charles Lyell, Esq., F. R. S., Author of the Principles of Geology, &c. In two Vols. 18mo, pp. 251 and 231, with plates. New York, Wiley & Putnam, 1845.—These volumes have been looked for with much interest by all classes of readers in this country; for while their author owes his reputation mainly to his scientific writings, he was also extensively known while here as an intelligent and highly educated English gentleman, who had opportunity and a disposition to observe the nature of American institutions and the state of society, as well as the relations of our rocks and their fossil contents. He has given the diary form to his travels, covering the period from July 20th, 1841, to Aug. 18th, 1842, during which time he was almost constantly on the wing, and actively engaged in geological observations. Sojourning in Boston, New York, and Philadelphia long enough to give a course of lectures on geology to audiences in each of those cities, to the first of which he was specially invited from England by the trustee of the "Lowell Institute," a well known institution for popular instruction.

No one interested in American geology can fail to give an attentive perusal to Mr. Lyell's "Geological Observations"—they are found scattered through these volumes with a liberal hand, in the order of his line of route, and are drawn up in the direct and felicitous style, with which all readers of the "Principles" and "Elements" of the same author are already familiar. The volumes are illustrated by Mr. Bakewell's bird's-eye view of the Falls of Niagara, colored geologically —and exposing the relative position of the several beds composing the cliffs at Queenston and in the rocky gorge of the Niagara river. He gives also a fac simile of Father Hennepin's view of the Falls as he saw them two hundred years ago, with the remarkable third schute or small fall transverse the British or Horse Shoe Fall, which has since disappeared ; (the same is given also in Mr. Hall's Final Report of the Geology of New York.) The sections at the Falls, of Goat Island, the Summer House, and the strata along the Niagara river from Lake Ontario to Lake Erie are somewhat the same also that Mr. Hall has given in his Final Report above mentioned. At p. 205, Vol. I, is a good lithographic plate of the remains of fossil mammalia, found by Mr. L. at Martha's Vineyard in the tertiary cliffs of "Gay Head." Vol. II is faced by a "geological map of the United States, Canada," &c., compiled by Mr. Lyell from various authorities which he cites in one corner of the map. We believe that Mr. Hall's map of a portion of the same regions, in his Final Report and the present, are the only *published* geological maps of the United States since the one by Mr. Maclure in 1817. Although the present one is confessedly very imperfect in many important points, it is still a valuable addition to our previous knowledge, and must serve as a useful guide until we are supplied with a better. There are also many wood cuts to illustrate several passages in the text.

Mr. Lyell's route in this country was mainly as follows : from Boston through Springfield by Connecticut River to New Haven, where he made, in company with Dr. Percival, and the editors of this Journal and others, an excursion to some of the trap hills and sandstone beds of the southern part of the new red sandstone of the Connecticut valley ; thence he went to New York, and by the Hudson to Albany. In company with Mr. Hall he crossed the state of New York and examined for the first time the Falls of Niagara, (he was there again the next year ;) he then went to western Pennsylvania, entering the coal region at Blossburg, and returning again via Seneca Lake and Geneva to Albany. He here rejoined Mr. Hall and examined two swamps in Albany and Green Counties, where mastodon remains have been found ; and after a tour to the Helderberg to see the upper Silurian strata and study their fossils in Mr. Gebhard's cabinet, he went to New York and Philadelphia. Mr. Conrad here accompanied him in a jaunt to the cretaceous strata of New Jersey, which occupied three days ; and on their return, Prof. Henry D. Rogers conducted him through the anthracite formation of Pennsylvania, and explained the curious structure and origin of the Apalachian chain. He then returned to Boston, where he was occupied during the six weeks following (Oct. 14) in his course of geological lectures before the Lowell Institute, making occasional excursions in the vicinity. From Boston he again returned to New Haven, and after a day's excursion with several gentlemen acquainted with the localities to the fish beds at Durham, he passed rapidly south to spend the severer months of a northern winter in examining the tertiary of the southern states. After leaving Washington City he examined the eocene marls of Schockoe Creek, near Richmond, and the miocene beds of James river below that city, in company with Mr. Ruffin, Jr., and descending the river he touched at Jamestown, Williamsburg and Norfolk, and passed rapidly on over the barrens of North Carolina and a corner of the "Great Dismal" to Weldon and Wilmington, and thence by steamer to Charleston, S. C. Without at present stopping at Charleston he hastened by railroad to Augusta, Ga. with the intention of examining the low country between the granitic region and the Atlantic, by following the course of the Savannah river from Augusta to Savannah, a distance of about two hundred and fifty miles. This he did by making frequent stops wherever it appeared that the inducement was sufficient, as at Shell Bluff near Demerry's Ferry, forty miles below Augusta, at Stony Bluff about seventy miles below where the "Burr stone" rocks appear, belonging to the eocene tertiary formation. Col. Jones of Millhaven conducted him to Jacksonborough, and other places of interest to a geologist. From Millhaven he proceeded by land to Savannah, about one hundred miles, where he arrived ten days after leaving Augusta. The vicinity of Savannah afforded him industrious employment in examining the mastodon and mylodon deposits at Heyner's Bridge on the White Bluff river, and also at Beauly and Vernon rivers. Returning by sea to Charleston, Dr. Ravenel accompanied our tourist on an excursion of a week up the Cooper river and Santee canal, where the mastodon and other interesting fossils were found abundantly when the canal was cut; they visited on this jaunt also the "Lime Sinks" in the vicinity of Vance's Ferry, the tertiary white marl and limestone of Cave Hall, the "Burr stone" on Stoudenmire Creek, and they returned to Charleston from Orangeburg by railroad. On his return north he stopped at Wilmington and collected eocene and miocene fossils, and visited several places on Cape Fear river, and at South Washington saw the same cretaceous beds containing *Belemnites*, &c. which appear in New Jersey, three hundred and fifty miles north. Mr. Ruffin and Mr. Tuomey were his companions in fossilizing in the tertiary beds near Petersburg in Virginia, and at Washington City he had an interview with the lamented Nicollet, and saw the cretaceous fossils brought by that zealous explorer and eminent astronomer from the Upper Missouri. Six weeks were now spent (Feb. 1, 1842) at Philadelphia in delivering a "short course" of geological lectures. Several weeks next succeeding were spent at New York in giving another course of lectures, during which Mr. Redfield accompanied him to Long Island while viewing the ancient and modern drift of that island. From New York he went again up the Hudson to view the greatly disturbed Silurian slates at Hudson City, and by railway to Chester and Westfield over the Taconic Mountains, composed of altered Silurian strata, out of which Dr. Emmons has constructed his "Taconic System."

At Worcester he saw the plumbaginous anthracite and mica schist and clay slates, and then paid a visit to Prof. (now Pres.) Hitchcock at Amherst, in company with whom he saw some diluvial phenomena near Amherst, and at Smith's Ferry near Northampton, they examined the red shales of the Connecticut, containing beautiful examples of fossil footprints; they ascend Mount Holyoke, and thence passed again to Boston, from which he made an excursion to the tertiary strata of Martha's Vineyard, and at Gay Head he collected the head of a fossil walrus and several cetacean vertebræ, sharks' teeth, a tooth of a fossil seal, casts of shells, &c: also kidney shaped masses one or two inches in diameter, which on analysis by Mr. Middleton proved to be coprolites, and contained over 50 per cent. of phosphate of lime. He considers these strata as belonging to beds decidedly newer than the eocene, to which they have been referred. April 25th, he returned to Boston and attended the third annual meeting of the Association of American Geologists, &c., of which he makes honorable mention, and after its close he set out on a tour for the valley of the Ohio, and the country west of the Alleghany Mountains, via Philadelphia and the national road from Cumberland in Maryland, stopping at Frostburgh long enough to examine the interesting coal and iron regions so finely developed there, in company with Capt. Green and other gentlemen, residents of that place. He no sooner entered the great hydrographical basin of the Ohio, than he was astonished at the richness and extent of the coal seams developed there, and which he saw finely exposed at Brownsville and Pittsburg. At Marietta, Dr. Hildreth conducted him to some of the interesting earthworks of the aborigines, as well as some of the uppermost beds of the coal measures, which he saw again at Pomeroy on his way to Cincinnati, where in company with Dr. John Locke he reascended the Ohio a hundred miles to see the rocks corresponding with the old red sandstone, and for this purpose went on shore at Rockville, where the equivalent of the Waverly sandstone of New York is seen, but greatly diminished in volume. While at Cincinnati he saw the excellent cabinets of Messrs. Buchanan, Anthony and Clarke, and then examined the quarries of blue limestone about the city from which their most valuable specimens were obtained. Mr. Buchanan and Mr. J. G. Anthony were his guides on an excursion to Big Bone Lick in Kentucky, about thirty three miles from Cincinnati, so celebrated for the bones of the mastodon as well as of many other extinct quadrupeds.

The alluvial banks and the origin of the natural drift of Ohio engaged his particular attention. From Cincinnati he crossed the state of Ohio to Cleveland on Lake Erie, where Dr. Kirtland took him to Rockport and the Rocky River to see the "lake ridges," similar to the "ridge road" of Lake Ontario—visiting Fredonia, celebrated for its natural supply of bicarburetted hydrogen gas used in illuminating the town; and from Buffalo he again visited Niagara, (June 5th, 1842,) and spent another industrious week in exploring its geology and ancient history, visiting for this purpose, Grand Island, Lewiston, St. Davids, and Queenston. (Some interesting results of this examination we must reserve to another occasion.) At Buffalo, Mr. Hayes showed him the diluvial furrows which the cherty limestone of that region has so well preserved. Leaving the United States he now visited Canada, touching at Toronto, Kingston, Montreal, Quebec, Three Rivers, and the Falls of Montmorency, at each of which places he made excursions and observations, accompanied by some resident gentlemen acquainted with the localities. He returned to the United States by La Prarie and Lake Champlain, and landed at Burlington in Vermont, where Prof. Benedict accompanied him to the falls of the Winooski, the boulder formation with shells at Port Kent, and the deep cleft formed by the Ausable River in the sandstone at Keesville, (Potsdam sandstone.) Crossing Vermont over the Green Mountains, he paid a visit to Prof. Hubbard at Dartmouth College in Hanover, N. H., and then returned to Boston by Concord, where he set sail on the 16th of July for Halifax, in the Caledonia steamship. He spent a month in investigating the interesting geological features of New Brunswick and Nova Scotia, and some of the results of his explorations have already been published by us (Vol. XLV, p. 353–356) in reference to the interesting erect fossil trees in the coal seams at South Joggins, (Cumberland,) the coal formations, gypsum, and marine limestones of Nova Scotia. He gives in his present volume, lists of fossil plants found in the coal measures of Nova Scotia, as well as the fossils of the lower carboniferous or gypsiferous formations of the same district.

It is plain from the foregoing itinerary, that Mr. Lyell made the best possible use of his time and opportunities while in this country; and it is equally plain, that on nearly every occasion he availed himself of the aid of the best and most experienced American geologists in exploring the places visited by him. It is only in this way that any man, however eminent and skillful he may be, can hope to arrive at correct geological conclusions respecting regions which must be new to him—presenting at every step an endless succession of novel objects, and which have required, it may be, years of patient and laborious investigation on the part of his geological guides, before conclusions are obtained and enigmas of complicated structure solved, which they can convey to a well informed geologist in a few hours, or at most a few days, in the rapid progress of a traveller's jaunt. Mr. Lyell could not in this respect have selected a more fortunate time to have informed himself about the geology of North America. Most of the state geological surveys were just closed, or near their close, and the eminent and experienced gentlemen who had conducted them were still warm in the harness, and ready to aid so distinguished a stranger in directing his inquiries, and in comparing notes with him regarding some of their conclusions; and it was much to their honor that they were willing to impart freely that knowledge for which they had toiled so long. In carefully perusing Mr. L.'s volumes, we have marked those parts which seemed to us of the greatest interest to the geologist, and regret that the limits of our present notice will not permit us to extract them—this we hope to do on a future occasion.

We have said nothing of the views taken by our traveller of the social, moral, and political aspect of things here, because these matters belong rather to our literary neighbors. But we must say in one word, that we have never read the journal of an English tourist who has seen our institutions in so just a light, whose discriminations were more fair, and whose criticisms were better worth regarding. We were also equally instructed and gratified by remarks in chapter XIII, on the state of education in the English universities—drawn out by what he saw of the general condition of educational institutions in this country.

It has evidently been no part of his plan in composing these volumes, to acknowledge every act of civility or hospitality which he received while here; and in neglecting to do so, he has best consulted the feelings of those most concerned, who opened their houses, not that they might appear on a tourist's pages, but that they might enjoy the society of an intelligent foreigner and his lady, who, whatever instruction or pleasure they might receive, were sure to return at least a full equivalent.

Now that Mr. Lyell has shown to his fellow laborers at home the interest and practicability of a geological and observational tour in North America, we trust that his example may be followed by some of his distinguished countrymen, whose lives and fortunes are so freely devoted to the cause of science.

2. *On the Liquefaction and Solidification of Bodies generally existing as Gases;* by MICHAEL FARADAY, (from the Phil. Trans., 1845, p. 155.)—In this paper Mr. FARADAY has given greater extension to his former researches on this subject, (Phil. Trans., 1823, pp. 160—189,) has devised methods by which he has added six substances, usually gaseous, to the list of those which have been primarily obtained in the liquid state; and has reduced seven, including ammonia, nitrous oxyd and sulphuretted hydrogen, into the solid form, beside revising and correcting previous results regarding the tension of vapor, &c.

The gases were, as in fomer experiments, subjected to considerable mechanical pressure and great cold by methods which we will briefly mention. Two air-pumps fixed to a table afforded the pressure, the first pump had a piston of one inch diameter, and the second a piston only half an inch in diameter, and these were so associated that the first pump forced the gas into and through the valves of the second, and then the second could be employed to throw forward this gas, already condensed to ten, fifteen, or twenty atmospheres, into its final recipient at a much higher pressure.

The gases on their way from the gas-holders to the pump were made to pass through a coil of thin glass tube contained in a refrigerator of ice and salt, and consequently at the temperature of 0° Fahr., by which means any water they contained was effectually condensed. The conducting tubes were of green bottle glass, from $\frac{1}{6}$ to $\frac{1}{4}$ inch in diameter, and from $\frac{1}{42}$ to $\frac{1}{30}$ inch in thickness, they were connected by caps, and screws, and cocks, with the pumps, and great care was taken that all parts of the apparatus should be perfectly tight. These tubes frequently sustained the pressures of fifty atmospheres in practice, and to prove their strength a hydrostatic pressure of one hundred and eighteen atmospheres was applied to one having an external diameter of 0·225 of an inch and 0·03 in thickness, without any fracture or any leak in the caps and cement; a tube having the thickness of 0·0175 of an inch and an external diameter of 0·24 of an inch, burst with a pressure of sixty seven atmospheres of fifteen pounds each to the square inch. One such as he formerly employed for generating gases under pressure, having an external diameter of 0·6 of an inch and a thickness of 0·035 of an inch, burst at twenty five atmospheres. The pressure gauge was as on former occasions a small tube of glass closed at one end, and having a cylinder of mercury moving in it. The graduation was marked on the gauge in black varnish and also in Indian ink; the latter stood, but the former was dissolved in some of the gases.

The cold bath in which the condensing tubes were immersed was formed of THILORIER's mixture of solid carbonic acid and ether, contained in a porcelain capsule of four cubic inches or more, fitted into a similar dish somewhat larger with three or four folds of dry flannel intervening; this bath continued from twenty to thirty minutes, retaining solid carbonic acid the whole time, and gave indication by an alcohol thermometer made for the purpose, of the very low temperature of −106° below 0° Fahr.; by placing the bath under an air-pump the temperature fell so low, on working the pump, as −166° below 0°,* or 60° below the tempe-

* Commencing with the temperature of −106°, as the exhaustion proceeded the temperature fell 6½° in the first ten inches of the barometer's rise, 8½° in the next ten, (or from ten to twenty inches of the barometer,) 4° in the next ten inches, 6° from twenty two to twenty four inches, 8° from twenty six to twenty seven inches, 7° in the next inch, 4° in the next, and 6° from 28° to 28½°, when the mercury became stationary.

rature of the same bath in the air. The vapor of carbonic acid, at this low temperature, given off from the bath, instead of having a pressure of one atmosphere had only a pressure (tension) of $\frac{1}{24}$ of an atmosphere or $1\frac{1}{2}$ inch of mercury. Carbonic acid mixed with ether is not more volatile at this temperature than water at the temperature of 86°; the ether was very fluid and the bath could be kept in good order for quarter of an hour. Mr. FARADAY thinks that these temperatures are all about 5° or 6° below the truth. With *dry* carbonic acid under the pump, the barometer attached was raised to 29 inches, while the external barometer was at 30 inches. Ingenious arrangements of apparatus were contrived, by which the condensing tubes could be submitted to this great cold under the air-pump receiver *in vacuo*, and the process of condensation examined in progess.

As many gases condense at a less pressure than one atmosphere when submitted to the cold of a carbonic acid bath in air, they were easily reduced by sending them through small conducting tubes into tubular receivers placed in the cold bath, and by a little management to seal them up hermetically in their condensed state. In this manner chlorine, cyanogen, ammonia, sulphuretted hydrogen, arseniuretted hydrogen, hydriodic acid, hydrobromic acid, and even carbonic acid were obtained sealed up in tubes, in the liquid state, and euchlorine was also secured in a tube receiver with a cap and screw plug. Mr. ADDAMS furnished the liquid carbonic acid to Mr. FARADAY in portions of 220 cubic inches each, which quantity produced carbonic snow enough for an active day's experiments of twelve to fourteen hours; the snow was preserved in a triple arrangement of concentric glass cylinders and interposed flannel.

Olefiant gas was condensed by the arrangements described, into a clear transparent fluid, but did not become solid even in the carbonic acid gas *in vacuo;* the pressure of the vapor of this substance at −103° Fahr. is singularly uncertain, being on different occasions and specimens, 3·7, 8·7, 5 and 6 atmospheres. This irregularity has not yet been resolved, but Mr. FARADAY suggests that there may be two or more substances physically and perhaps chemically different, in olefiant gas, and varying in proportion with the circumstances of heat, proportions of ingredients and attending circumstances. This fluid dissolves resin.

Hydriodic acid is obtained as a solid at −60° Fahr., and then its vapor has a pressure of less than one atmosphere; at a little higher temperature it becomes a liquid, and its vapor has then nearly one atmosphere of pressure. As a solid it is perfectly clear, transparent, and colorless; having fissures or cracks in it resembling those that run through ice. It dissolves the cap cement and bitumen of the gauge graduation, and appears to act on fat as it leaked by the plug of the stop-cock with remarkable facility; it also acts on the brass of the apparatus and the mercury in the gauge. Hence the following results of pressures and temperatures are to be considered only as approximations, viz. at 0° Fahr. pressure was 2·9 atmospheres; at 30°, 3·97 atmospheres; and at 60°, 5·86 atmospheres.

Hydrobromic acid, prepared from the perbromide of phosphorus, condensed into a clear liquid at 100° below 0°, or lower—and has not the pressure of one atmosphere at the temperature of the carbonic acid bath in air. Its elastic force is less than that of muriatic acid, but it obstructs the motion of the mercury in the gauge, so that its results could not be relied on. At and below 124°, it is a solid, transparent, crystalline body. It melts at 124°, but does not freeze until reduced much lower than this.

Fluosilicon, was liquefied under a pressure of about nine atmospheres, at the temperature of 160° below 0°, and was then clear, transparent, colorless and very fluid, like hot ether. It did not solidify. It acted on the lubricating fat of the stop-cock and caused some leakage, and there was no liquid in the tube at common temperatures; but when cooled to 32° some fluid appeared, and a bath of ice and snow caused a still more abundant condensation.

Phosphuretted hydrogen.—This gas was carefully prepared to free it from phosphorus, and cooled to 0°, to free it from water, and by these means a pure, clear, colorless, transparent and very limpid fluid appeared, which could not be solidified by any temperature applied, and which, when the pressure was taken off, immediately rose again in the form of gas. There seemed, from the mode of its behavior, to be another gas present, not so condensable as phosphuretted hydrogen, which may perhaps be either another phosphuretted hydrogen or hydrogen itself.

Fluoboron, like *fluosilicon*, required the lowest temperature to reduce it to the fluid state, when it was a very limpid, colorless, clear fluid, showing no signs of solidification, but when at the lowest temperature mobile as hot ether.

The foregoing are, it is believed, new results of the liquefaction and solidification of gases. The following have been before made liquid, but some additional facts are now stated.

Muriatic acid did not freeze at the lowest temperature; the liquid dissolves bitumen and softens the resinous cap cement. At −100° its pressure is 1·80 atmospheres, at −92° 2·28, at −83° 2·90, at −53° 5·83, at −33° 8·53, at 22° 10·66, and at −5° 13·88, at 28° 23·08, at 32° 26·20; the result formerly obtained was 40 atmospheres at 50° Fahr.

Sulphurous acid becomes a crystalline, transparent, colorless solid, at 105° Fahr.; when partly frozen the crystals are well formed. This solid is heavier than the liquid acid, and sinks freely in it; at 14° Fahr. its pressure is one atmosphere, at 32° 1·53, and at 100° 5·16 atmospheres.

Sulphuretted hydrogen, was solidified at 122° below 0° Fahr., and is then a white crystalline, translucent substance, not remaining clear, and transparent, in the solid state, like water, carbonic acid, and nitrous oxide, but forming a mass of confused crystals like common salt, or nitrate of ammonia, solidified from the melted state. It fuses at temperatures above −122° and the solid part sinks freely in the fluid, indicating that it is considerably heated. The tension of its vapor is at −100° 1·02 atmospheres, at −58° 2 atmospheres, at 0° 6·10, and at 52° 14·60.

Carbonic acid, when the snow of THILORIER is melted (at −72° Fahr.) and re-solidified by a bath of low temperature, appears as a clear transparent, crystalline, colorless body, like ice—so clear as to deceive the eye ; it is heavier than the fluid bathing it, and has at −70° or −72° a pressure of 5·33 atmospheres. M. CAGNIARD DE LA TOUR has shown that, at a certain temperature, and under a sufficient pressure, a liquid becomes clear transparent vapor, or gas, having the same bulk as the liquid. At this temperature, or one a little higher, it is not likely that any additional pressure, however great, would convert the gas into a liquid. Mr. Faraday thinks that this state comes on with carbonic acid at about 90° Fahr. Mr. F. obtained the following pressures from carbonic acid by his recent experiments :

Fahr.	*Atmospheres.*	*Fahr.*	*Atmospheres.*
−111°	1·14	−15°	17·80
−107	1·36	0	22·84
− 95	2·28	4	21·48
− 83	3·60	5	24·75
− 75	4·60	10	26·84
− 56	7·70	15	29·09
− 34	12·50	23	33·15
− 23	15·45	32	38·50

Euchlorine is easily converted into a solid crystalline body, having the color and general appearance of bichromate of potassa. At 75° below 0° it melts into an orange-red fluid, in which the solid part sinks. It gives off no vapor when solid.

Nitrous oxide was obtained as a beautiful, clear, crystalline solid at about −150°, and then had a pressure of less than one atmosphere. The cold produced by its evaporation is very great, and in certain cases it seems probable that this substance may be employed in procuring degrees of cold far below any yet obtained. Its vapor has the same irregularity of pressure, which was found in olefiant gas, and it seems probable that two substances are present, one more volatile than the other. At —40° its pressure is 10·20, at 0° 19·05, at 30° 35·82 atmospheres respectively.

Cyanogen had been previously made solid by Bunsen; the solid melts at −30°; one volume of the liquid gas at 63° gave 393·9 volumes at the same temperature, and the thermom. barometer 30·2 inches. This gives the specific gravity of the liquid as 0·866, if 100 cubic inches be considered as weighing 55·5 grains. Its tension at 0° is 1·25, at 32° 2·37, at 103° 7·50 atmospheres.

Ammonia may be obtained as a white, translucent, crystalline substance, melting at 103° below 0°, at which point the solid is heavier than the liquid. The specific gravity of the liquid is 0·531 at 60°. Its tension at 0° is 2·48, at 32° 4·44, at 60° 6·90, at 83° 10 atmospheres.

Arseniuretted hydrogen was not solidified at −166°; chlorine, ether, alcohol, sulphuret of carbon, caoutchoucine, camphine or rectified oil of turpentine, did not freeze at −166°. Hydrogen oxygen, nitrogen, nitric oxide, carbonic oxide and coal gas, did not liquefy at —166°, when subjected to 27·27, 50·50, 40 and 32 atmospheres of pressure respectively. Hydrogen gas leaked freely at a pressure of twenty seven atmospheres in an apparatus which was tight with nitrogen at 50 atmospheres. No degree of mere pressure has ever yet solidified a liquid, and when a greater degree of cold can be commanded than at present, (as may be done with nitrous oxide,) it is probable that other gases may be liquefied.

3. *On the Geological Constitution of the Altai;* by M. P. de Tchihatcheff.—This elaborate memoir has been reported upon at length and with high commendation, before the Royal Academy of Sciences at Paris, by Brongniart, Dufrénoy and Elie de Beaumont, and their report is published in the Comptes Rendus, vol. xx, May, 1845. From its pages we cite the following. The Russian Altai chain occupies an area about four times that of Switzerland, and has a curving direction, with the convexity of the curve turned to the southwest. On the south, as Humboldt states, the older formations of the Asiatic continent prevail, while within the curvature there is a vast area of ancient diluvial deposits. The chain as laid down by M. Tchihatcheff continues to the China coast, following the course of the river Yenissei. The general statement just made, for the most part holds true also of this eastern portion. The contour of the ridges is generally rounded, owing to the predominance of schistose rocks. Porphyry and granite are common, and serpentine occurs in some places; but gneiss is met with only as a variety of granite. The stratified rocks are mostly of the Silurian and older formations. The carboniferous formation was distinguished at three localities—near Rydersk, Tyrianoosk and Salaïr. M. Tchihatcheff distinguishes two grand systems of ranges—one the *occidental* Altai, running from N. W. to S. E.; and the other the *oriental* Altai, from N. E. to S. W. The highest peak, Belouhha, called also the columns of

Katoune, is 12,789 feet (English) in height, and stands nearly at the intersection of the two systems, just as Mt. Blanc stands at the intersection of corresponding systems in the Alps. The oriental chain is parallel in position with the principal Madagascar and African ranges.

4. *Whitney's Translation of Berzelius on the Blowpipe.*—(Die Anwendung des Löthrohrs in der Chemie und Mineralogie von J. Jacob Berzelius. Vierte verbesserte Auflage mit 4 Kupfertaflen. Nürenberg, verlag von Johann Leonhard Schrag. 1844.)—The use of the Blowpipe in Chemistry and Mineralogy. By J. J. Berzelius. Translated from the 4th enlarged and corrected edition ; by J. D. Whitney. Boston, 1845. 12mo. pp. 237. J. D. Ticknor. With plates.

A well executed translation of Berzelius's long celebrated work on the blowpipe, is a most acceptable addition to the library of every chemist and mineralogist.

Mr. Whitney has presented us with such an one, and the mere announcement of the fact is all that is required to insure its general adoption. With the high character of the work all are too well acquainted to need any information on this point at our hands. There can be no doubt, that the timely appearance of this translation will materially aid the progress of mineralogical and chemical science in this country.

5. *Fownes' Chemistry for Students.*—(A Manual of Elementary Chemistry, theoretical and practical. By George Fownes, Ph. D., &c. London, 1845. 12mo. pp. 566. Also an American edition, by Dr. Robert Bridges of Philadelphia. Lea & Blanchard.)

Dr. Fownes, by his Actonian prize essay, is already favorably known to the general reader as an author; this pleasing production having been extensively circulated in this country. The present work occupies an important middle ground between the more extensive systems of higher cost, and the numerous throng of chemical text books of minor range. It is perspicuous in style, and in the main well digested. Some of its arrangements of topics might be fairly criticised on any accepted principles of classification, but on the whole it will be found a most valuable book. The organic portion is particularly well executed, and much fuller than is usual in books of equal volume.

6. *Lieut. Wright's Treatise on Mortars.*—(A brief Practical Treatise on Mortars: with an account of the processes employed at the public works in Boston harbor. By. Lt. W. H. Wright, U. S. corps of engineers. Boston, W. D. Ticknor & Co. 1845. 12mo. pp. 148. With 7 plates.)

This very useful little volume is evidently the result of practical experience in the art of construction ; it is lucid in arrangement, sufficiently full in detail, and well composed. He considers first the calcareous minerals, and the limes which they furnish. Next, the various materials employed in the preparation of mortars—in this chapter under the head of sand, he says, (p. 25, Art. 53,) "sand performs no chemical part in mortars, but is entirely passive in its influences," &c. This seems to us too broad an assertion, as it is by no means certain that caustic lime does not form a combination with the silica of fine sand in mortar, and this circumstance (the formation of an insoluble silicate) may exert an influence in the final consolidation of calcareous cements. This does not interfere with the generally accepted opinion, that mortars owe their chief consistency to the gradual conversion of the lime into carbonate.

The general composition of mortars and their resistance; the fabrication of limes in the large way; the preparation and application of various kinds of mortars; concrete and some of its applications, and the theory of the solidification of mortars—are made the subjects of distinct chapters, all of which contain interesting and important information; but the last, especially, commends itself to the attention of chemists, as embracing some curious and valuable results obtained by Lt. Kendrick of the artillery, and Assistant Professor of chemistry at West Point Military Academy. These researches had for their object to determine the cause or causes of the *hydraulic* powers of certain cements—a question which has had many proposed solutions. Bergman and Guyton de Morveau, who were the first to investigate this subject, attributed the hydraulic power to the presence of a minute quantity of oxide of manganese in the limestones from which the specimens examined by them were obtained.

"Mr. Smeaton, an English engineer, had remarked however as early as 1756, the curious fact, that the existence of *clay* in a calcareous stone, gave it the property of indurating under water; and Saussure discovered that the lime of Chamouni, though entirely without manganese, was nevertheless hydraulic, and with reason inferred, that this property depended on the clay which existed in the lime. Subsequent researches confirmed this opinion. In 1817, M. Vicat (a well known writer on cements) formed hydraulic cements synthetically, by calcining mixtures of common lime and clay. His experiments proved that clay imparted hydraulic properties to lime, and manufactories were established for making water cements by the mixture of the two substances.

In Lt. Kendrick's experiments the pure ingredients of each composition were thoroughly mixed by the mortar and pestle, and in the proportions stated in the table. If lime or magnesia was used, it was previously slacked with hot water; if the carbonate of either was employed, it was moistened, and the material subsequently heated in platinum crucibles, open, but in a close stove. The comparative hardness was ascertained by a test needle $\frac{1}{20}$ of an inch in diameter, which was held firmly in a vertical position, and the specimens were submitted to trial without being removed from the vessel containing them.

The following is Lt. Kendrick's table of results, with some unimportant omissions.

No. of trials.	Silica.	Alumina.	Carbonate of lime.	Lime.	Magnesia.	Potassa.	Intensity of heat.	Duration of heat.		Time required for setting.			Resistance in pounds, after				
													days. 5	days. 10	days. 15	days. 20	days. 25
								h.	m.	d.	h.	m.	lbs.	lbs.	lbs.	lbs.	lbs.
1	37·75	12·25		200		3	low-red	2	45	1			7				10
2	40		357=	200		5	"	2	30	3			2·75	7		9·50	10
3	40		357=	200			red	3			5		7		15		
4	56·60	18·40	357=	200		5	highest	5			16		2·75	7		9·50	
5	25	13		128	77		red	2	30				7			16	
6	25	13		200			"	2	30		18		3·75	4·75		5·50	
7	50	15	357=	200			"	3	45		18		2·50	9	11	23	
8	50		357=	200			"	3	30		15		4	10	17	24	
9	50			200			"	2		2	16		2·75	7	10	11	
10	60·90	19·10			160		"	1	45	1	16		3	6·50	16	28	
11	40			200		2	"	3		4			1·50	5·25	7	8	
12	40			121	77		"	1	30	4			2·00	13	16	20	
13	25			100			"	2		2					3 50		
14	25			100	65		"	2		1			12	20	22		
15	75·50	24·50			200		"		40		7		15	17·50			
16	113·25	36·75		200			"		50		1	30	17	24			
17	113·25	36·75			200		"		30			45	23	26			
18	37·75	12·25			200		"		30			30	17	25			
19	75·50	24·50			200		"		45	1			6·50	16			
20		40		100	67		"		48		17		16	16			
21		25		100			"		48		18		3·50	3			
22		40			100		"		29		16		21	26			
23				119·50	80·50		low-red	4									
24				119·50	80·50		red		38								
25				119·50	80·50		highest		30								
26	6	2		114	78		red		23	6							2
27				150	100		"		23								
28				100	60		highest		20								
29	8·10	3·70		100	60		low-red		30		21		4·50				
30	8·10	3·70		100	60		red		30	1	4		2				
31	8·10	3·70		100	60		highest		20	1	14		5				
32				140	100		red		27								
33	25	10		140	100		"		27	4				2			
34	60			180			highest		30		14					10	
35	75			150			"		30	1	3					10	
36	58			140			"		20	1						11	
37	53·60	46·40		200			"		30		1	55					24
38	53·60	46·40		100			"		30		14						8
39	50·58	16·42		200			"		30		17						8
40	37·75	32·25		83·60	56·40		"		30		12						20
41		40			100		"		30							11	
42				150	100		red		45								

"In addition to the above, a series of experiments was performed by Lt. Kendrick, with the view of testing the hydraulic virtues of the *oxide of manganese*, but in no instance, where this substance was mingled with pure lime, did he succeed in obtaining any good result, nor was he more fortunate in substituting pure magnesia in the place of the oxide of manganese ; as appears from the table, Nos. 23, 24, 25, 27, 28, 42.

" The positive results exhibited in the table, are more to be relied on and lead to more safe conclusions. The examination of them shows :

" 1st. That silica and lime employed together, without any other admixture, will give a hydraulic compound. Nos. 3, 8, 9, 11, 13, 34, 35, 36.

" 2d. That silica, alumina and lime will produce an equally energetic composition. Nos. 1, 4, 6, 7, 16, 37, 38, 39. In some respects, the addition of alumina improves the mixture. Being insoluble in water, it protects the outer portions of the lime from solution, until the union of the latter with the silica is effected, and prevents the free permeation of water through the mortar, which might greatly injure its quality.

" 3d. That silica, alumina and magnesia, will form a good hydraulic compound, without the addition of lime, Nos. 10, 17, 18, 19.

" This fact may account for the existence of hydraulic qualities in the native carbonate of magnesia, which, like the carbonate of lime, may frequently contain a portion of clay in its composition.

" 4th. That silica, lime and magnesia give a better hydraulic result than silica and lime, Nos. 11, 12, 13, 14. This probably arises from the formation of double silicates, the silicic acid uniting with both lime and magnesia.

" Nos. 21, 22, 41, exhibit surprising results, and lead to the inference which is *generally* deducible from the table, that the induration of hydraulic mortars is not to be ascribed to any one agent, nor ever to precisely the same causes; though, in most cases, it is owing to the formation of a *silicate*.

" With the view of discovering (says Lt. Wright) the constituents of some of our hydraulic limes, I submitted for analysis to Dr. Jackson of Boston, two specimens of limestone, obtained from different localities and possessed of different properties. They both furnish after calcination, products, which it is necessary to pulverize, in order to prepare them for use, and are both known in commerce as hydraulic cements ; one called Barnes' Connecticut cement, from Southington, Conn., the other Lawrence's Rosendale cement, from the vicinity of Rondout, New York.

" The second is esteemed the best cement for use, setting in five minutes after immersion in water.

" The results of the two analyses were as follows :—One hundred grains of the Connecticut cement, being thoroughly dried at 212° F. yielded on chemical analysis—

		Oxygen.	
Siliceous and ferruginous sand,*	8·780 grs.		
Silicic acid,	23·620	12·275	18·135.
Carbonic acid,	8·000	5·788	
Sulphuric acid,	0·137	0·072	
Lime,	47·285	13·281	18·190.
Alumina,	6·120	2·941	
Peroxide of iron,	3·260	0·998	
Magnesia,	1·920	0·760	
Manganese (oxide of),	0·100	0·077	
Potash,	0·792	0·133	
	100·014		
	·014 gain, ashes.		
	100·000		

Oxygen of the acids=18·135
Oxygen of the bases=18·190

"One hundred grains of the Rosendale cement yielded, on analysis, as follows:—

		Oxygen.	
Silicic acid,	18·170 grs. con.	9·439	12·93.
Sulphuric acid,	1·000	0·598	
Carbonic acid,	4·000	2·893	
Lime,	44·970	12·630	
Magnesia,	19·080	7·360	12·291.
Alumina,	5·500	2·563	
Peroxide of iron,	4·900	1·501	
Oxide of manganese,	1·000	0·464	
Potash,	0·673	0·114	
Soda,	0·438	0·112	
Water,	0·200	0·177	
	99·931		

The oxygen of the acids is, 12·930
" " " lime is, 12·630
" " " other bases is, 12·291

"From which it would seem that bibasic compounds are formed when the cement sets.

"On comparing the analyses with each other, it appears that the chief constituents of the Connecticut cement are silica and lime, whereas a large proportion of magnesia enters into the composition of the Rosendale. The inference suggested by the results of the table is thus strengthened by those of the analyses, viz. that the increased energy of the latter cement may be ascribed to the formation of double silicates.

"Dr. Jackson, who has performed many experiments with hydraulic mixtures, informs me, that the oxide of manganese will answer the same

* The sand is not in chemical combination, but is mechanically mixed with the other ingredients of the cement.

purpose as magnesia: which is not surprising, as the two substances are isomorphous.

"Prof. W. B. Rogers, of the University of Virginia, has analyzed within the last six years upwards of a hundred specimens of cement rocks derived from the carboniferous and Apalachian series of Virginia and other states; and he believes the cause of the solidification of the products, obtained by calcining both those classes of rocks, to be the formation of silicates: in the former chiefly those of lime and oxide of iron; in the strikingly hydraulic Apalachian limestones, those of lime and magnesia."

In Vol. XLVI, p. 30, we have given from Dr. Beck's Report on the Mineralogy of New York, a table of analyses of the hydraulic limestone of that state, together with some general remarks on this subject.

7. *Dissertation on a Natural System of Chemical Classification;* by Oliver Wolcott Gibbs, of the city of New York.—In this work the author proposes a new and complete system of chemical classification for the elementary bodies founded on their analogies, in crystalline form or isomorphism, their relations to each other in their mode of combination and the molecular type of their compounds.

He remarks, "Between the fifty six elements to which all matter has been resolved, there exist numerous remarkable analogies which separate them first into subordinate natural families or groups, and then by general, though not indistinct resemblances, unite them into one indissoluble chain, each link of which *differs in degree rather than in kind* from its fellow on either side, so that the whole illustrates, in unorganized nature, the truth of the maxim of Linnæus—'*Natura non facit saltum*'—Nature makes no leaps. And this, then, we assume as the fundamental idea and central point of our essay; namely that this law of grades, which Linnæus announced for the organized kingdom alone, *is an universal law*, and prevails as well among shapeless atoms as among living beings, and in the simplest crystals as well as in the innumerable complex forms in which life outwardly manifests itself."

The author here alludes to some of the points in which analogies may be shown to exist; and first, the relations which exist between the equivalents of bodies, which are such that a natural group of elements have generally either the same equivalent, or else the relation of their equivalent numbers may be expressed by a very simple relation. This resemblance is too marked and general to be regarded as mere coincidence.

"If we admit that the specific gravities of bodies represent the relative weights of equal bulks, it follows, that if we divide the specific gravities by the atomic weights, we obtain the relative numbers of equivalents, which different substances contain under the same bulk or volume; these have been called the atomic numbers, and we find the atomic numbers of the elements are often connected by simple ratios, and that substances of the same natural group have usually the same number of equivalents contained under the same volume."

The combining volumes of substances have evidently an important relation to the atomic numbers, as also the atomic volumes, obtained by dividing the equivalent weights by the specific gravities, and which may be considered as expressing the relative volumes of their atoms.

Another and very interesting point, is that of resemblance in crystalline form, for we find as a general rule, that those bodies closely resembling each other in chemical properties have the same crystalline form.

Late researches have tended to confirm the law announced by Dulong and Petit, that the specific heats of equivalent weights of bodies are equal, or are connected by simple multiples.

But to come to the classification itself. The elementary bodies are divided into fourteen classes, of which we can say little more than to mention their names.

The first group embraces eight members. Oxygen, sulphur, selenium, tellurium, chlorine, bromine, iodine and fluorine. These are connected by their strong affinities for the substances of the other groups, by the fact that any one of them may replace another, wholly or in part, in any compound without altering its molecular type, and without altering in kind its chemical relations. Very close relations are also observed between their equivalents and atomic volumes, and several of them are connected by isomorphism. They are also the most highly electro-negative of all substances.

The second group consists of nitrogen, phosphorus, arsenic and antimony.

The third of hydrogen, zinc, cadmium, and magnesium; the salts of the three last are well known to be isomorphous, and Dr. Kane has pointed out a close resemblance between the compounds of zinc and hydrogen, so that it is not improbable that if hydrogen could be sufficiently condensed it would appear as a metal.

The fourth is composed of iron, manganese, chromium, cobalt, and nickel; the natural resemblances are pointed out in a clear and forcible manner, but our limits will not permit us to give any thing more than the groups and the substances composing them.

The fifth consists of aluminum, glucinum, and zirconium.

The sixth of molybdenum, tungsten, vanadium and columbium.

The seventh group comprises copper, mercury, bismuth and palladium.

The eighth is composed of barium, strontium, calcium, lead and silver.

The ninth group consists of platinum, titanium, iridium and osmium.

The tenth embraces gold, uranium, rhodium and tin.

The eleventh comprises potassium, sodium and lithium.

The twelfth consists of yttrium and thorium.

The thirteenth of cerium, latanium, didymium, erbium and terbium.

The fourteenth comprises carbon, boron and silicon. The author proposes to reduce the received equivalent of boron and silicon by one third, and thus assimilate their acids in constitution to carbonic acid; thus CO_2, BO_2, and SiO_2, and certainly, the general analogy of boracic and silicic acids, to the carbonic, in their chemical relations, and the great simplification which it would introduce in our views of the composition of the natural silicates, appear to offer some ground for the proposed change.

The arrangement of the compounds is one obviously growing out of the system adopted for the elements, and we will only mention the principles of his classification.

"1st. The compounds of the members of group first with one another are arranged according to their molecular type.

"2d. The compounds of the members of any other group than group first, with the members of group first, are arranged together in groups according to molecular types principally, and according to isomorphism wherever isomorphisms exist."*

Although we have presented but an imperfect outline of Mr. Gibbs's principles of arrangement, we may safely say that he has ably shown the gradation by which the different substances are united to each other, and fully vindicated the motto of his essay, "*Natura non facit saltum.*"

8. *New Books Received.*—Among numerous, interesting, and important works on our table, we have space in this number to note the titles only of the following:

I. A History of Fossil Insects in the Secondary Rocks of England, accompanied by a particular account of the strata in which they occur, and of the circumstances connected with their preservation. By Rev. PETER B. BRODIE, M. A., F. G. S. 8vo., pp. 130, plates 11. London, J. Van Voorst. 1845.

II. Report intended to illustrate a map of the hydrographical basin of the upper Mississippi River, made by (the late) J. N. NICOLLET while in employ under the Bureau of the corps of topographical engineers. Washington, 1843. (With a large map.)

III. The Encyclopedia of Chemistry, theoretical and practical; presenting a complete and extended view of the present state of chemical science. Part IX, ending with *cobalt.* pp. 464.

IV. North American Sylva: MICHAUX and NUTTALL. Vol. IV, 2d half, royal 8vo. pp. 57 to 136. 23 plates.

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* Mr. Gibbs acknowledged his indebtedness to Drs. Kane and Graham, for the aid he has derived from their published suggestions on this subject.

MISCELLANIES.

FOREIGN AND DOMESTIC.

1. *On the Hypothesis of Electric Currents in the Nerves;* by M. Matteucci.—Never having been able, in our former experiments, to establish, by aid of the galvanometer, the existence of electric currents in the brain, the spinal cord, or in the nerves of the dog, the rabbit, and the frog, we wished to make a new trial on an animal of large stature, (*the horse,*) hoping by this means to place ourselves in the most favorable condition for researches of this kind.

The galvanometer which we employed in these new experiments was constructed by Rumkorff, and was extremely sensible; the conducting wire, making two thousand five hundred convolutions, was furnished at each of its extremities with a *platinum plate,* fixed on an ivory handle, and so varnished as to leave only a square centimètre of its surface exposed. The needle made one oscillation in seventy seconds.

Before applying the two platinum plates to the nervous parts, they were immersed in spring-water for a very long time, and until the signs of the current, which are always observed at the first immersion, had completely disappeared.

These precautions having been taken, and the live horse having been thrown down upon a table, its sciatic nerve was insulated from the neighboring muscles (by means of varnished silk) for a length of thirty or forty centimètres, (upwards of one foot,) was carefully wiped, and left in communication with the cerebro-spinal axis.

After being well assured that the needle constantly remained at zero, although either one or other of the platinum plates was removed from the water and alternately reimmersed, the plates were placed in contact, first with the surface of the sciatic, then, after the neurilemma had been removed, with different points of this voluminous nerve.

The interval of deviation, namely, the distance comprised between the two plates, being at first 3 or 4 cent., the needle sometimes remained at zero, and at other times deviated several degrees, soon returning to zero. This interval having been suddenly extended to 15 cent., the deviation ought to have been notably increased, in the same direction, if electric currents existed in the nerves. There was nothing; or rather the needle did not deviate to a greater number of degrees than in the preceding case, and its deviation was still only momentary, or else was entirely wanting.

It is important to bear in mind that during the continuance of these experiments, in consequence of the pain which was voluntarily excited in the animal, its posterior train was the seat of energetic and repeated efforts, and that, consequently, the extremities of the galvanometer were put into communication with the sciatic nerve at the very moment when it was transmitting the exciting influence to the muscles of the thigh and leg.

If, by varying our trials, we have occasionally perceived a very sensible deviation of the needle, it is important to notice *that this deviation did not change in direction, although the contacts were inverted;* that, moreover, it so occurred every time that the nerve was touched *simultaneously* with the two plates of the galvanometer. At the moment when these plates were successively plunged into water deviations were also obtained, which did not differ from those that are observed on inserting the extremities of the instrument in the nerve itself.

Bearing in mind the extreme sensibility of our galvanometer, the favorable condition of the experiment, and the precautions which we have taken, we think we are authorized in concluding that there does not exist any trace of electric currents in the nerves of living animals appreciable by the instruments we at present possess. In addition we may add, that our previous researches had already conducted us to the same conclusion. —*Elect. Mag. Vol. I,* 1845, p. 495—497.

2. *New Researches on Animal Electricity: on the Muscular Current, and on the Proper Current;* by M. Matteucci. (Compt. Rend., April, 1845.)—In order to complete all that relates to the muscular current, I must first mention that I have very distinctly obtained signs of tension with the condenser at the two extremities of my muscular piles. I have also obtained signs of *electro-chemical decomposition* by the muscular current. That which particularly interested me in these new researches was to study, in a much more complete manner than I had hitherto done in my preceding labors, on the one hand, the relation between the intensity and the duration after death of the muscular current; and on the other, the activity of respiration and the circulation of the blood, the temperature of the medium in which the animal lives, and its rank in the animal scale. I have labored at this for five months, every day submitting to experiment a certain number of frogs, that had been taken from the same pond. Of these frogs, some were immediately killed, in order to obtain a measure of the muscular current; others were placed at the temperature of the external atmosphere, in an apparatus by means of which I could know the quantity of carbonic acid gas given out by a frog in a determinate time; others, finally, were placed in an ambient medium, the temperature of which was constantly 16°, (61° Fahr.) I thus operated on frogs that had lived from—4° (25° Fahr.) to 16°. The result of so great a number of experiments left me not the smallest doubt as to this conclusion,—the intensity of the muscular current is in proportion to the activity of respiration. I operated in like manner upon frogs which had been preserved for a greater or less length of time in water *deprived of air,* and which, therefore, were in a more or less decided state of asphyxia. I always arrived at the same result.

By operating upon several warm-blooded animals, I verified in a more complete manner the result to which I had already arrived, namely, that the intensity of the muscular current is proportionate to the rank of the animal in the scale of beings; whilst the duration of this current after death varies in an opposite ratio. I wished to study the influence of different gases upon the intensity and duration of the muscular current. For this purpose I arranged an apparatus that permitted of my having a muscular pile in a certain gaseous medium, with power to open and close at pleasure the circuit of this pile with the galvanometer. I operated thus in atmospheric air, in oxygen, in very rarefied air, in carbonic acid, and in hydrogen. In these different media the muscular pile acted equally, both as regards intensity and duration. Hydrogen gas alone presented a singularity which could not have been anticipated before the experiment. This singularity is not referable to an action of the gas on the muscles, but rather to a phenomenon of secondary polarity, which is verified, whatever be the source of the current. The fact is, that on operating in this gas with a muscular pile, the deviation remains constant for several hours. This nullity of action of the different gases named, upon the intensity and duration of the muscular current, plainly proves that the origin of this current is in the muscle itself, whether living or taken from the animal a short time after death. This same conclusion is rendered evident by another experiment. I prepared with very fine intestinal membrane, a great number of small conical cavities; these cavities I filled with fibrine separated from the blood of a recently killed ox; I rapidly prepared with these elements a pile that was in appearance similar to my piles of half thighs. I obtained no sign of a current from this pile. This pile acted with the same result both in oxygen and hydrogen. It is, therefore, in the muscle, and consequently in its organization, and in the chemical actions which are going on within its very structure, when it belongs to a living or to a recently killed animal, that the cause of the current exists.

The most curious results to which I have arrived in these latter labors, are in relation to the proper current of the frog. I am now able to affirm *that this current does not belong exclusively to the frog*, but that it is manifested in all the muscles of all animals, provided that these muscles present at their extremities an unequal tendinous termination. All the muscles that have on one side the tendinous extremity more compacted, more condensed than on the other, give the current direction in the muscle from the tendinous extremity to the surface of the muscle. I have verified this result on all the muscles of the frog, on the muscles of the superior as well as those of the inferior limbs; on the muscular masses of the pigeon, the rabbit, and the dog. If I have rightly understood the latest anatomical labors made upon the structure of muscles, or their relations with the tendons and the sarcolema, I cannot hesitate in regarding the proper current, or that from the tendon to the surface of the muscle, as the most simple case of the muscular current. The tendinous fibres are continued among the muscular fibres, whilst the sarcolema merely envelopes the said muscular fibres. This result is rendered still more probable when we call to mind that the same laws preside over the proper current and the muscular current.—*Elect. Mag.*, *Vol. II*, 1845, p. 20—22.

3. *Structure of Electro-precipitated Metals;* by WARREN DE LA RUE.—Mr. Rue shows that in copying an engraved plate by precipitation, the copy is imperfect along the centre of each groove or depressed line, the two parts though apparently joined, being not so in reality. This difficulty and the porosity proceeding from the crystalline texture of the deposit, may be remedied by thoroughly tinning it at the back as soon as the cast is removed from the matrix; the tin insinuates itself into a great number of the pores, and binds the whole firmly together. With the help of a little chloride of zinc the tinning is effected very readily, and it should be done without disturbing the structure by filing. Owing to the porous texture of electro-precipitated plates, they cannot be used for any purpose where strength is required.—*Proceed. Chem. Soc., part* 13, p. 300.

4. *Electric Sound.*—M. Jacobi has constructed an acoustic telegraph, in which the sound resulting from the interruption of the electric current is repeated one hundred and fifty to two hundred times in a second. The sound produced is transmitted to a distance of fifteen miles, (twenty four kilometres.)—*L'Institut*, *No.* 600, 25 *Juin*, 1845, p. 231.

5. *An Account of Compact Aluminum;* by Prof. F. WÖHLER of Göttingen.—The author has lately found, contrary to the results of his former researches on aluminum made eighteen years ago, that this metal is readily fusible, and that in its reduction from the chloride of aluminum by means of potassium, it presents itself in the form of fused globules, generally so small that their shape is not distinguishable under the microscope, although occasionally they are met with having a sensible diameter. He effects the reduction at once in a clay crucible, the bottom of which he covers with pellets of pure potassium, and places upon these the chloride of ammonium, covering the whole with chloride of potassium in powder. The crucible being then closed up, and heated in a coal fire, the reduction is instantly effected.

Fused aluminum has the color and lustre of polished tin; it continues perfectly white in the air; it is fully malleable, and the globules may be beaten out into the thinnest plates without cracking at the edges. It is entirely unmagnetic. In other respects the metal in this compact state has the properties which the author formerly ascribed to it.—*London, Edinburgh, and Dublin Phil. Mag.*, *May*, 1845, pp. 450, 451.

6. *Superoxyd of Silver.*—On passing an electrical current through nitrate of silver, metallic silver collects at the negative pole, and a substance of a blackish gray color, crystallized in octahedrons, which Ritter called superoxyd of silver. Wallquist obtained for it the formula $Ag\,O_2$, and finds that the same oxyd is contained also in the solution operated upon. Fischer operating by the same process, obtained a substance for which he gives the formula $\dot{A}g\,\overset{\cdot\cdot\cdot\cdot\cdot}{N}+4\,\ddot{A}g+2\dot{H}$.—*Annal. der Chem. und Phar.* lii, 258.

7. *The blue color of Gold Leaf viewed by transmitted light.*—M. Dupasquier has shown that this same color is presented by different metals reduced to a state of extreme thinness, or in a fine powder suspended in water. He established this fact by operating on silver, antimony, bismuth, metallic arsenic in powder, sulphuret of antimony, binoxyd of manganese, sulphuret of lead, arsenical cobalt, and many other metallic ores.—*L'Institut, July*, 1845, p. 247.

8. *Xanthine.*—Dr. Unger, who has found the xanthic oxyd in guano, finds that this oxyd forms definite compounds with acids and also with basic oxyds, and proposes to call it xanthine. Several of these compounds he has investigated and described.—*Chem. Gaz. July* 15, 1845, p. 296, *from the Proceedings of the Berlin Academy, April*, 1845.

9. *A curious change in the composition of Bones taken from Guano;* by R. Warrington, Esq. (Proceed. Chem. Soc., part 10, p. 223.—This substance derived from the alteration of bones, has a highly crystalline laminated structure, with a white color slightly tinged with yellow. It is readily soluble in hot distilled water, with the exception of some brown particles distributed in certain parts. On examination by chemical tests, it was found to consist principally of sulphuric acid, potash, and ammonia with a little uric acid, and analysis led Mr. Warrington to consider it a compound mainly of sulphate of potash and sulphate of ammonia, in the proportion of 4 equivalents of the former to 1 of the latter. The existence of the potash in the midst of the guano abounding in soda and ammoniacal salts, he accounts for by supposing it to have come from the ashes of fires made in former times by sealers.

10. *Detection of Kinic Acid;* by John Stenhouse.—To examine a bark for kinic acid, boil a little with a slight excess of lime, pour off the liquor and concentrate it; filtering is not necessary. Then distill it mixed in a retort with half its weight of sulphuric acid and peroxyd of manganese. If the bark contains the smallest quantity of kinic acid, the first portion of the liquid distilled over has a yellow color and the very peculiar smell of *kinone.* If the liquid is treated with a little ammonia, it be-

comes deep brown, changing in a few minutes to brownish black; or if chlorine water be added to another portion, it changes from yellow to a bright green. The distillation need not be long continued as the kinone is very volatile.—*Proceed. Chem. Soc., part* 10, p. 226.

11. *On the decomposition of Salts of Ammonia at the ordinary temperature;* by H. BENCE JONES, M. D.—Dr. Jones shows that evaporation, even at the ordinary temperature, of salts of ammonia, causes their decomposition by the escape of the ammonia. A solution of the sulphate of ammonia, at first neutral to the test liquids, after a while changed litmus to pink; other salts produce the same result. A solution of the urate after standing for a while, presented minute tufts of crystals of uric acid along the edge of the liquid.—*Proceed. Chem. Soc., part* 10, p. 244.

12. *Styrole.*—The oil of storax was named styrole, by E. Simon, who obtained it from the liquid storax of the shops by distillation with water. Its properties have been investigated by J. Blyth and Dr. A. W. Hoffman at Berlin. It is colorless, with a burning taste, and aromatic odor, resembling a mixture of benzole and naphthaline. It evaporates at all temperatures, and boils at 145¾° C. A wick dipped in it burns with a brilliant smoky flame. This substance consists, according to their analyses, of 2 equivalents of carbon and 1 of hydrogen, and has analogies with benzole and cinnamole.—*From the Proceed. Chem. Soc., part* 13, 1845, p. 334.

13. *Salicine;* by M. PIRIA.—Salicine is a natural combination of grape-sugar and of saligenine; the saligenine again is a substance which is very readily altered by chemical reagents. Weak acids convert it into saliretine, concentrated sulphuric acid into rutiline, nitric acid into carbazotic acid, oxidizing agents into hydruret of salicyle, potash in a state of fusion into salicylic acid.

When salicine is submitted to the action of any agent whatever, two cases may occur:—1. If the agent is sufficiently energetic to decompose at the same time the saligenine and the sugar, altered products of these two substances are obtained, as if the experiment were made on a mixture of saligenine and grape-sugar. 2. If, on the contrary, a weak agent is employed, the saligenine only is decomposed and the sugar remains unaltered, but it combines with the modified saligenine. Thus chlorine first converts it into chlorosalicine; then into bichlorosalicine; lastly, into perchlorosalicine: these are combinations of sugar with the saligenine, in which chlorine has replaced 1, 2, 3 equivalents of hydrogen.

Dilute nitric acid changes salicine into helicine. This results from the combination of the sugar of the salicine with the hydruret of salicyle derived from the oxidation of the saligenine. When helicine is submitted to the action of chlorine or bromine, the hydruret of salicyle which it contains is converted into chloride and bromide of salicyle; these products combining with the sugar give rise to chlorohelicine and bromohelicine.

Lastly, all these combinations of saligenine, or its derivatives with sugar, are rapidly decomposed by contact with acids and by synaptase.—*Chem. Gaz., August*, 1845, p. 323.

14. *Composition of Fungi;* by Dr. F. Schlossberger and Dr. O. Doepping.—Fungi have been known to be remarkable for the nitrogen they contain, and their nutritive qualities have been attributed partly thereto. Drs. Schlossberger and Doepping have found, by analysis of several species, that many contain, dried at 212° F., two or thee times as much nitrogen as wheat, (some 77 per. cent.,) and a considerable proportion of phosphates. In nearly all the species they examined, they detected *mannite* or *fermentable* sugar, and many of the succulent fungi (A. russula, cantharellus, emeticus) when preserved for some days in a bottle with a narrow neck, but not closed, passed spontaneously into spirituous fermentation, emitting at the same time an agreeable odor like musk, and yielding alcohol afterwards on distillation. The substratum of the fungi consists mainly of *cellulose.* No *amylum* was detected by the iodine test.

15. *Action of Animal Charcoal;* by R. Warrington.—Beer or ale, and the solutions or decoctions of various astringent bitter substances, as oak bark, Peruvian bark, strychnia, lose their bitter taste when passed through charcoal. 12 grains of animal charcoal were found sufficient by Mr. R. Warrington, to remove the bitter flavor of 2 grains of disulphate of quina dissolved in two ounces of distilled water. A large quantity of sulphate of magnesia was removed from its solution by the same means, and also chloride of barium, sulphate of soda and other salts. This subject, the action of animal charcoal on metallic salts, is under investigation by M. Chevallier.—*Proceed. Chem. Soc., part* 13, p. 326.

16. *Thomaite; a new mineral species.*—This name is given by Mayer to a carbonate of iron found in the Siebengebirge, having the same crystalline form with Junkerite, but having the specific gravity 3·10, a pearly lustre, and granular fracture. After exposure to the air for two days the color changes to a pale honey yellow, and the mineral becomes dry and compact. It consists of protoxyd of iron 53·72, silica 6·04, alumina 4·25, lime 1·52, magnesia 0·43, protoxyd of manganese 0·65, carbonic acid 33·39=100. (Leonhard's Jahrbuch, 1845. Heft. 2, p. 200.)—*Jameson's Jour., July*, 1845, p. 196.

17. SCHEERER *on Aventurine Feldspar.*—Aventurine feldspar has been found by Scheerer to owe its iridescence to minute crystals of specular iron or titanic iron, instead of mica as generally stated. Scheerer concludes from his various microscopic investigations of minerals, that the microscope should be used before attempting an analysis, especially with cleavable minerals which are especially liable to mechanical mixtures. (Poggendorf's Annalen, lxiv.)—*Jameson's Jour., July*, 1845, p. 195.

18. *Spadaite, a new mineral;* by VON KOBELL.—This species is near Schiller-spar in composition. *Color* reddish or flesh-red, *streak* white, *lustre* glistening or glimmering, *hardness* 2·5, compact with an imperfectly conchoidal fracture; soluble in muriatic acid with a residuum of gelatinous silica. Its formula is $4MS^3+M\,Aq^4$. (Berz. Jahresl. 24th. Jahrg. 281.)—*Jameson's Jour., July*, 1845, p. 194.

19. *Descriptions of Polycrase and Malacrone, two new minerals;* by SCHEERER.—These minerals are generally associated with orthite, and are often accompanied with phosphate of yttria at Hitteröe, Sweden. The polycrase is near polymignite. It is without cleavage and has a conchoidal fracture, breaking easily. *Sp. gr.* 5·105, *color* pure black; thin splinters translucent and yellowish brown, *streak* grayish brown, *lustre* inferior to that of polymignite. A qualitative analysis afforded titanic acid, columbic acid, zirconia, yttria, oxyds of iron, uranium, cerium, with traces of alumina, lime, and magnesia. Malacone, is so called from its having inferior hardness to zircon. Its form is similar but not identical; *cleavage* none, *fracture* conchoidal, *hardness* 6, *sp. gr.* 3·903, *color* bluish-white, though often brownish, reddish or yellowish from a coating of foreign substances. *Lustre* vitreous, but resinous on a surface of fracture. *Translucent* in small fragments and of a yellowish-white color. *Streak* colorless. *Composition*, silica 31·31, zirconia 63·40, oxyd of iron 0·41, yttria 0·34, lime 0·39, magnesia 0·11, water 3·03=98·99. It appears to be a zircon containing water. Scheerer considers it probable that the zirconia exists in malacone in a different isomeric condition from the zirconia in zircons. (Keilhau's Gaea Norwegica.)—*Jameson's Jour., July*, 1845, p. 192.

20. R. PHILLIPS, Jr., *on the State of Iron in Soils.*—Mr. Phillips shows by his analyses that in most rich soils the iron is found principally in the lower state of oxydation, and urges that the presence of this oxyd is not injurious to vegetation. He explains thus the fact that this oxyd remains unchanged; the peroxyd, he states, is converted to protoxyd by means of the affinity of the carbon of the organic matter or humus for oxygen. This he appears to confirm by experiments. He adds as follows:—

The non-fertility of bog-earths may, it appears to me, be perhaps accounted for from the organic acid they have been found to contain; supposed to be the suberic acid, but probably an acid peculiar to these earths. The action of the manures usually employed to bring them into a state of fertility, viz. lime and strong oil of vitriol, is made apparent if we take this view, for by uniting with the first the organic acid would be rendered innoxious, whilst the second would destroy it; but neither of these agents would have any influence on the further oxydation of the iron, and the second would render it soluble; and what makes this idea more probable is, that I have found in all rich soils a soluble organic salt of lime to exist, and that these soils never possessed any acid properties. The poisonous character of the drainage water from these earths is explained by this view; but, on the other supposition, that it results from the action of protoxyd of iron, we can hardly imagine,—knowing as we do how immediately, when held in solution by carbonic acid, it is decomposed by exposure to the action of the atmosphere,—that these injurious effects could take place in the short time that would elapse before it became sesquioxyd; and I have before pointed out that the soluble organic matter would have *no* effect in arresting this decomposition. The use of the red oxyd of iron in a soil has been stated to be its power of retaining ammonia. I must confess, however, I am rather inclined to doubt that it is of any great value to it, on account of this property, as all soils containing much of it are found to be of poor quality; but, admitting this to be the fact, there does not appear to me to be any reason to doubt that this retentive power is equally possessed by the protoxyd.

From the above observations I was led to the conclusion, that the preservative action of the humus on the protoxyd of iron in soils was probably analogous to that of sugar in some pharmaceutical preparations, particularly in that of the saccharated carbonate of iron of the Edinburgh Pharmacopœia. I therefore prepared some of it by the process there given, and found, on passing a current of air over a portion of it by the apparatus I have before described, that a small amount of carbonic acid was given out from it. I do not, however, wish to be considered as speaking positively as to this being the action of the sugar, although the experiment shown above would appear to render it probable.

Note.—Since writing the above communication, I have had brought before my attention a remark occurring in several agricultural works, that some clays require either burning or long exposure to the atmosphere before they are fitted to be mixed with fertile soils; and as the iron in them is found to become peroxyd during these operations, it has been brought forward as another proof of the injurious action of the protoxyd of iron.

In my opinion, however, it is not because the iron is in the state of protoxyd that clays require this treatment, but on account of its existing as sulphuret, which, as is well known, is hurtful to vegetation; and I believe that the appearance of oxydation assumed by them during exposure to the atmosphere, is nothing more than the decomposition of the sulphuret into peroxyd of iron. That this decomposition would take place under these circumstances I may instance, in the case of an embankment of clay on the Croydon railway, where, accompanied by the formation of sulphate of lime, it occurred so extensively as to destroy part of the work.

I have, on analysis, usually found deep clays to contain sulphuret of iron; and another proof of its existence in them may be adduced from the slaty clay usually accompanying the coal formation, where it is found so extensively as to be employed for the manufactures of alum and copperas.—*London, Edinburgh and Dublin Phil. Mag., May*, 1845, pp. 440, 441.

21. *Sillimanite.*—Dr. Thomson has lately obtained for the composition of this mineral the following: silica 45·65, alumina 49·50, protoxyd of iron 4·10=99·25, which is the same as that given for Bucholzite.—*Phil. Mag.*, XXVI, 1845, p. 536.

22. *On the origin of Quartz and Metalliferous Veins;* by Prof. GUSTAV BISCHOF, of Bonn. (Jameson's Jour., April, 1845, p. 344.)—The author opposes the theory of injection of the material constituting quartz veins in a state of fusion, and advocates the view of their originating from aqueous solutions. The article is worthy of being cited entire. The following are interesting facts with regard to the prevalence of silica in solution in cold water:—

There is scarcely any water, whether it be spring or river water, which does not contain silica in solution, though frequently in very small quantities. Should such water penetrate through the narrowest cleft, there is the possibility that more or less of the dissolved silica may be deposited in it. It is true, that such a deposition supposes that the water, either, being hot, cools during circulation in the cleft, or evaporates; or that other substances maintaining the silica in solution are precipitated; but we must not overlook other circumstances from which this precipitation may arise. Very many phenomena show that there exists a peculiar affinity between *silica and organic substances or organic remains.* As an example, I may mention that in the wooden piles of Trajan's Bridge, near Vienna, quartz concretions—agates even of half an inch in thickness—have been found; and that, according to observations of Glocker, it is only on a lichen that *Hyalite* is formed on the serpentine of the Zobtenberg. If, now, in the above instances, the wood of the bridge pile has induced a precipitation of silica from an extremely dilute solution, such as the water of the Danube presents—if, in like manner, a lichen has occasioned such a precipitation, from, probably, equally dilute solutions, then it is easy to understand, that organic remains in a Neptunian rock, as in clay-slate, may likewise effect a precipitation of silica.

23. *Mean Height of the Continents above the Surface of the Sea;* by Baron von HUMBOLDT.—Since immense and lofty chains of mountains occupy our imaginations, by presenting themselves as evidences of vast terrestrial revolutions, as the boundaries of climates, as great watersheds, or as the bearers of different vegetable worlds; it becomes so much the more necessary to show, by a correct numerical estimate of their volume, how small the whole quantity of the elevated masses is in comparison with the area of entire countries. The mass of the Pyrenees, for example—a chain, the mean height of whose summits, and the superficial extent of whose base, are known by accurate measurements—would, if distributed over the area of France, increase the height of that country only 115 English feet. The mass of the eastern and western chains of the Alps would, in the same manner, raise the height of the flat country of Europe by only 21·3 English feet. By means of a laborious investigation, which, from its very nature, only gives the upper limit, i. e. a number which may be smaller, but cannot be larger, I have ascertained that the centre of gravity of the volume of the land which rises above the present level of the sea, is situated at a height of 671 and 748 English feet in Europe and North America, and 1131·8 and 1151 English feet in Asia and South America.* These calculations indicate the lowness of the northern regions; the great steppes of the plains of Siberia are counterbalanced by the enormous swellings of the surface of Asia between lat. 28½° and 40°, between the Himalaya, the northern Thibetian Kuen-Lun, and the Sky Mountains. We can, to a certain extent, determine, from the estimated amounts, where the plutonic force of the interior of the globe has operated with greatest power in elevating continental masses. The mean height of the non-mountainous portion of France does not exceed 512 English feet.—*Jameson's Jour., July,* 1845.

24. *Infusoria.*—Ehrenberg has examined various tufas and other beds in volcanic regions, and finds that they often consist largely of infusoria. His investigations were made upon specimens from Patagonia, Ascension Island, the Rhine, Pompeii, Mexico, Chili, and other regions, and he shows their connection with the formation of opal and other siliceous deposits. The tufaceous rocks of the Hochsimmer volcanic hill, near the Laacher-Sea, contains the infusoria in a '*roasted*' condition, and of thirty eight species found, only two were new.

Ehrenberg proposes to distinguish rocks without infusoria by the general term *Stœchiolitic,* alluding to their pure or simple character; but when they contain infusoria, they are styled *Hydrobiolitic*:—or if connect-

* The corresponding amount for the whole globe will consequently be somewhat less than 1000 feet.

ed with volcanic operations, and changed by volcanic heat, ***Pyrobiolitic;*** and tufas containing infusoria he calls ***Pyrobiolite.*** When the infusoria are of fresh-water origin, the deposit is described as ***Hydrozoolitic***, and when marine, ***Halizoolitic.**** It may be doubted whether the science stands in need of these terms.—***Proceedings of the Berlin Academy, April,*** 1845.

25. *On the Kunker, a Tufaceous Deposit in India;* by Capt. NEWBOLD.—The kunker is a more or less compact tufaceous deposit of carbonate of lime or silica. Capt. Newbold brings evidence to prove that they were produced from springs of water, remains of which may in some instances be detected. The vast kunker deposits in the plains and valleys of India are sometimes upwards of seventy feet deep, overspreading places where they could not have been formed from rivers or rivulets. Along the edges of trap dykes mounds of kunker are occasionally observed, like those around the mouths of kunker-depositing springs. In the Kurnool territory, there is a warm spring from which deposits of a calcareous mud are forming. But around it and below there is a bed of kunker partly siliceous, in some portions of which fresh-water shells—Melaniæ, some Planorbes, and others, and impressions of leaves, are contained. The shells afford instructive examples of the various stages of fossilization. Some of their coats have been completely converted into sparry carbonate of lime; others have been filled and remain as casts when the exterior shell is broken off. Others again are lined with drusy crystals of quartz; in some, this siliceous crystallization is just beginning to roughen the surface of the interior, and is hardly perceptible without the aid of a lens, thus exhibiting interesting examples of the processes by which fissures in rocks are lined and filled up with minerals which we look in vain for in the enclosing walls. Some of the kunker is so firm as to resemble the siliceous tufa deposited by the hot springs of Iceland. Capt. Newbold states that the siliceous deposits are apparently of older date than the calcareous, and were probably formed when the waters of the supposed springs had a somewhat more elevated temperature.—*Phil. Mag.* 1845.

26. *On some of the Substances which reduce Oxide of Silver and precipitate it on Glass in the form of a Metallic Mirror;* by JOHN STENHOUSE, Ph. D.—It has long been known that aldehyde, when heated in a tube with ammonio-nitrate of silver, reduces the oxide to the metallic state, and forms a brilliant coating on the inner surface of the tube.

* The above names are derived as follows:—stœchiolitic, from στοιχειον, *an element;* hydrobiolitic, from υδωϱ, *water*, and βιον, *life*, and λιθος, *stone;* pyrobiolitic, from πυϱ, *fire*, and the same as the last; hydrozoolitic, from υδωϱ and ζωον, *animal;* halizoolitic, from αλς, the *sea*, and ζωον, *animal*.

Three other substances, saccharic acid, salicylic acid and pyromeconic acid, were also known to possess the same property, though the coatings which they yield are much darker, and therefore less beautiful than those formed by aldehyde. This was the state of our knowledge previous to the announcement, about six months ago, of Mr. Drayton's process for silvering mirrors in the cold, by means of ammonio-nitrate of silver and an alcoholic solution of the oils of cloves and cassia.

I find that the number of substances which, especially when assisted by heat, give more or less brilliant coatings of reduced silver, is much greater than has hitherto been supposed. Thus grape sugar forms a pretty brilliant mirror even in the cold. When unassisted by heat the mirror is rather slowly formed, requiring from six to twelve hours; but when a slight heat is applied it forms very readily in the course of a few minutes; the coating is much darker than that produced either by aldehyde or by Drayton's process. Cane sugar also yields a mirror when assisted by heat, but none in the cold. Gum-arabic and starch also yield dark colored mirrors, but more slowly, and require considerable boiling: so do phloridzine and salicine. Oils of turpentine and laurel also give mirrors, but with still greater difficulty, the solutions requiring to be very concentrated. Resin of guaiacum acts in a similar manner.

Oil of pimento, as is well known, consists of two oils, one an acid oil, which is heavier than water, and forms crystalline compounds with the bases; this in the course of a few minutes, even in the cold, produces as brilliant a coating of silver as the mixture of the oils of cassia and cloves. The neutral portion of the pimento oil, which is lighter than water, does not reduce nitrate of silver even after long boiling. I could not succeed in forming metallic mirrors with cinnamic, benzoic, meconic, komenic, tannic, or pyrogallic acids, with gum benzoin, elemi or olibanum, with oil of rhodium or with glycerine.

Ingenious as Mr. Drayton's patent process certainly is, it labors under a very serious inconvenience, which I greatly fear will not be easily remedied. In the course of a few weeks the surfaces of the mirrors formed by his process become dotted over with small brownish-red spots, which greatly injure their appearance. The cause of the spots seems to be this—that the metallic silver while being deposited on the surface of the glass carries down with it mechanically small quantities of a resinous matter, resulting, most probably, from the oxidation of the oil. This resinous matter, which is interposed between the glass and the silver, in the course of time begins to act on the metallic surface with which it is in contact, and to produce the small brown spots already mentioned. If an excess of the essential oils is employed to precipitate the silver, the metallic mirror is much darker, and gets sooner discolored than usual. No doubt the alcohol present in the solution keeps up much of the resinous matter; still a little of it is almost always deposited on the silvered surface, and acts in the injurious way described.—*Proceedings of Chem. Soc., Part* **10.**

27. *New Self-registering Barometer;* by Robert Bryson. (Trans. Roy. Soc. of Edinb., xv, 1844, 503.)—The arrangement in Mr. Bryson's instrument is as follows:—In the open end of a siphon barometer tube, there is a float consisting of an ivory ball, which rests on the mercury, and a float rod extending out of the extremity. This float rod is bent at right angles at top and shaped to a knife edge, to act as the registering rod; and near it a tin cylinder, about three inches in diameter marked with the hours, is made to revolve by machinery, once in twenty four hours. In this cylinder there is a series of short pins corresponding to the hours, which, as the hour arrives, acts upon a bent lever, which presses the registering rod against the cylinder, upon which an impression is thus left, indicating the height of the barometer at the time. On passing the pin, the rod is thrown back by a spring, which is sufficient to shake the float and remove any adhering mercury. Mr. Bryson, who describes minutely his mode of arrangement, proposes that there should be seven cylinders, each marked with a day of the week. To fit them for use they are streaked with chalk and water well levigated and applied by a camel's hair brush.

28. *On the Manufacture of Enamelled Cast Iron Vessels in Bohemia.*—Iron pots, and especially those of enamelled cast iron, are very extensively used in domestic economy. To enamel these vessels, they are cleaned as perfectly as possible with weak sulphuric acid, then washed with cold water, and dipped into a thin paste made with quartz first melted with borax, feldspar, and clay free from iron, then reduced to an impalpable powder, and sufficient water added to form a rather thin paste. These vessels are then powdered in the inside with a linen bag containing a very finely pulverized mixture of feldspar, carbonate of soda, borax, and a little oxyd of tin. Nothing then remains but to dry the pieces and heat them in an enamelling furnace. The coating obtained is very white, resists the action of fire without cracking, and completely resists acid or alkaline solutions.—*Chem. Gaz., July,* 1845. p. 290.

29. *The Tagua Nut or Vegetable Ivory;* by A. Connell. (Trans. Roy. Soc., of Edinb., xv, 1844, p. 541.)—This remarkable seed is now extensively carved into a variety of ornaments, which resemble the finest ivory both in texture and color. The nuts are often as large as a hen's egg and somewhat angular in shape, and come from a species of palm, (Phytelephas macrocarpa.) Excepting the outer shell, about $\frac{1}{30}$ of an inch thick, and a brown epidermis, they consist throughout of the close grained material called vegetable ivory. Its density is 1·376 at 53° Fahr. The analysis afforded Mr. Connel, gum 6·73, legumin or vegetable casein 3·8, vegetable albumen 0·42, fixed oil 0·73, ashes 0·61, water 9·37, lignin or other woody matter 81·34=100. The ashes contained phosphate of lime, sulphate of lime, chlorid of calcium, carbonate of lime and a little silica.

30. *Lithographic Stones.*—A new locality affording a superior quality of lithographic stone has been opened at Belbèze, Haute Garonne, in the French Pyrenees. According to M. Leymerie they are inferior to none before known, being even superior in hardness to the stone from Munich. This locality belongs to the cretaceous formation, while all previously discovered have been found in the jurassic system of rocks.—*L'Institut*, 9 *July*, 1845. p. 245.

31. *On the Leaves of the Coffee Tree as a Substitute for Tea.*—Prof. Blume of Leyden laid before the meeting of naturalists of Bremen samples of tea prepared from coffee leaves, which in appearance, odor, and taste of the decoction agreed entirely with that from genuine Chinese tea. It has long been employed as such by the lower classes in Java and Sumatra.—*Chem. Gaz., July* 15, 1845, p. 299, *from Buchner's Repertor. für Pharm.*, XXXVII, p. 34.

32. *Upon Anastatic Printing.* (Translated from Dingler's Polytechnic Journal, June, 1845.)—Prof. Faraday lately delivered a lecture at the Royal Institution upon Anastatic printing, the recent discovery which enables us to reproduce to an unlimited extent and in a very short time, the impressions of any kind of printing, whether ordinary type work, engravings on copper, or lithographs. The theory of Anastatic printing is based upon the well known properties of the substances employed in the process. For instance there is, as we are aware, an attraction in water for water; oil, as we know, attracts oil, whereas these two substances repel each other. Metals are far more readily moistened by oil than by water, but more readily still by a weak solution of gum; and with even yet greater facility by water in which phosphoric acid is dissolved. In addition to these properties thus possessed by water, oil and the metals, the following may be looked upon as the fundamental principle of Anastatic printing, namely, the facility with which the ink of a newly printed book or engraving may be transferred by pressure to another even surface.

The impression of a recent newspaper, for instance, when laid upon a white sheet of paper may be transferred to the latter by pressure, so that all its letters will be distinctly reproduced thereupon. This will enable us to comprehend readily the process of Anastatic printing.

The printed paper, be it type or an engraving, is first to be moistened with dilute nitric acid and then powerfully pressed by means of a roller into the surface of an even zinc plate, by which means every part of the sheet is brought into immediate contact with the zinc. The acids with which the white portions of the paper are saturated attack the metal, the printed portions thereof being simultaneously transferred to its surface, so that the zinc plate after this process presents a reversed copy of the printed object. The principles above alluded to are now brought to bear. The zinc plate thus prepared is to have poured over it a solution of gum in diluted phosphoric acid. This fluid is attracted by those portions of the plate that the acid has previously attacked and moistens them without difficulty, whereas it is repelled by the oil contained in the transferred portion of the printer's ink. The plate is now to have an inked roller passed over it, whereby the very reverse action is brought about. The repulsion between the oil of the ink and the moist surface of the plate over which the roller is passed, prevents the grease from adhering to those portions of its surface upon which there are no printed lines or strokes, while from the attraction of oil for oil, the ink is retained upon all the printed parts. The Anastatic plate is thus ready for use, and impressions may be thrown off from it as in the ordinary lithographic process.

Prof. Faraday described likewise the method of obtaining, by the Anastatic process, copies of antique originals, the ink of which is no longer transferrable by simple pressure. The process is as follows:—The printed paper is first to be laid in a solution of potash and subsequently in a solution of tartaric acid. The consequence thereof is that all the blank portions of the paper become penetrated by minute crystals of tartrate of potash, and as this salt repels water, an inked roller may then be passed over the surface of the paper without the ink adhering to any parts but where the ink of the impression is. The tartrate is then to be removed by careful washing, and the operation proceeded with as above described, beginning by moistening the paper with dilute nitric acid.

The February number of the Art Union informs us, that as yet the Anastatic process is only used in London, and that on a small scale, at the printing office of Mr. Wood, Bargeyard Chambers, Buchlersbury. The impressions which it is desired to reproduce may be either from recent or from old originals, (a hundred years old indeed or more;) their age is quite immaterial; the copies produced being in every case equally excellent, so much so indeed, that they are not to be distinguished from the originals themselves.

By means of this process old or faded engravings and etchings may be so renovated as to have all the appearance of recent impressions. One special merit in the invention lies in the method resorted to, and that with complete success, for preventing the extension of the ink when exposed to any pressure to which it may be submitted, and by which means the finest lines and the sharpest outlines are reproduced with the greatest precision. When ordinary type is transferred by this new process to a zinc plate, the impressions which the latter affords have precisely the appearance, as they leave the press, of being taken from metal types; and as in this new method of printing the impressions are not transferred to stone but to zinc, which may be used with the ordinary steam-presses in the form of cylinders, we have it in our power to multiply to any extent both text and illustrations in the cheapest and in the most rapid manner. There is a single printer in London whose stereotype plates are valued at £300,000, an outlay which this discovery renders henceforward unnecessary. What advantages for printers, booksellers, and the public!

33. *On a gigantic bird sculptured on the tomb of an officer of the household of Pharaoh;* by Mr. Bonomi.—In the gallery of organic remains in the British Museum, are two large slabs of the new red sandstone formation, on which are impressed the footsteps or tracks of birds of various sizes, apparently of the stork species. These geological specimens were obtained, through the agency of Dr. Mantell, from Dr. Deane, of Massachusetts, by whom they were discovered in a quarry near Turner's Falls. There have also been discovered by Captain Flinders, on the south coast of New Holland, in King George's Bay, some very large nests measuring twenty six feet in circumference and thirty two inches in height; resembling, in dimensions, some that are described by Captain Cook, as seen by him on the northeast coast of the same island, about 15° south latitude. It would appear, by some communications made to the editor of the Athenæum, that Prof. Hitchcock, of Massachusetts, had suggested that these colossal nests belonged to the Moa, or gigantic bird of New Zealand; of which several species have been determined by Prof. Owen, from bones sent to him from New Zealand, where the race is now extinct, but possibly at the present time inhabiting the warmer climate of New Holland, in which place both Capt. Cook, and recently Capt. Flinders, discovered these large nests. Between the years 1821 and 1823 Mr. James Burton discovered on the west coast or Egyptian side of the Red Sea, opposite the peninsula of Mount Sinai, at a place called Gebel Ezzeit, where for a considerable distance the margin of the sea is inaccessible from the Desert, three colossal nests within the space of one mile. These nests were not in an equal state of preservation; but, from one more perfect than the others, he judged them to be about fifteen feet in height, or, as he observed, the height of a camel and its rider. These nests were composed of a mass of heterogeneous materials, piled up in the form of a cone, and sufficiently well put together to insure adequate solidity. The diameter of the cone at its base was estimated as nearly equal to its height, and the apex, which terminated in a slight concavity, measured about two feet six inches, or three feet, in diameter. The materials of which the great mass was composed were sticks and weeds, fragments of wreck, and the bones of fishes; but in one was found the thorax of a man, a silver watch, made by George Prior, a London watchmaker of the last century, celebrated throughout the East, and in the nest or basin, at the apex of the cone, some pieces of woollen

cloth and an old shoe. That these nests had been but recently constructed was sufficiently evident from the shoe and watch of the shipwrecked pilgrim, whose tattered clothes and whitened bones were found at no great distance; but of what genus or species had been the architect and occupant of the structure Mr. Burton could not, from his own observation, determine. From the accounts of the Arabs, however, it was presumed that these nests had been occupied by remarkably large birds of the stork kind, which had deserted the coast but a short time previous to Mr. Burton's visit. To these facts, said Mr. Bonomi, I beg to add the following remarks:—Among the most ancient records of the primeval civilization of the human race that have come down to us, there is described, in the language the most universally intelligible, a gigantic stork bearing, with respect to a man of ordinary dimensions, the proportions exhibited in the drawing before you, which is faithfully copied from the original document. It is a bird of white plumage, straight and large beak, long feathers in the tail; the mail bird has a tuft at the back of the head, and another at the breast: its habits apparently gregarious. This very remarkable painted basso-relievo is sculptured on the wall, in the tomb of an officer of the household of Pharaoh Shufu, (the Suphis of the Greeks,) a monarch of the fourth dynasty, who reigned over Egypt, while yet a great part of the Delta was intersected by lakes overgrown with the papyrus,—while yet the smaller ramifications of the parent stream were inhabited by the crocodile and hippopotamos,—while yet, as it would seem, that favored land had not been visited by calamity, nor the arts of peace disturbed by war, so the sculpture in these tombs intimate, for there is neither horse nor instrument of war in any one of these tombs. At that period, the period of the building of the great pyramid, which, according to some writers on Egyptian matters, was in the year 2100 B. C., which, on good authority, is the 240th year of the deluge, this gigantic stork was an inhabitant of the Delta, or its immediate vicinity; for, as these very interesting documents relate, it was occasionally entrapped by the peasantry of the Delta, and brought with other wild animals, as matters of curiosity to the great landholders or farmers of the products of the Nile,—of which circumstance this painted sculpture is a representation, the catching of fish and birds, which in those days occupied a large portion of the inhabitants. The birds and fish were salted. That this document gives no exaggerated account of the bird may be presumed from the just proportion that the quadrupeds, in the same picture, bear to the men who are leading them; and, from the absence of any representation of these birds in the less ancient monuments of Egypt, it may also be reasonably conjectured they disappeared soon after the period of the erection of these tombs. With respect to the relation these facts bear to each other, I beg to remark that the colossal nests of Capts. Cook and Flinders, and also those of Mr. James Burton, were all on the sea shore, and all of those about an equal distance from the equator. But whether the Egyptian birds, as described in those very ancient sculptures, bear any analogy to those recorded in the last pages of the great stone book of nature, (the new red sandstone formation,) or whether they bear analogy to any of the species determined by Prof. Owen from the New Zealand fossils, I am not qualified to say, nor is it indeed the object of this paper to discuss; the intention of which being rather to bring together these facts, and to associate them with that recorded at Gezah, in order to call the attention of those who have opportunity of making further research into this interesting matter.—*Athenæum*, (*London*,) *June*, 1845.

34. *On the Heat of the Solar Spots;* by Prof. Henry, of Princeton College, New Jersey.—Sir D. Brewster read an extract of a letter which he had just received from Prof. Henry, who had recently been engaged in a series of experiments on the heat of the sun, as observed by means of a thermo-electrical apparatus applied to an image of the luminary thrown on a screen from a telescope in a dark room. He found that the solar spots were perceptibly colder than the surrounding light surface. Prof. Henry also converted the same apparatus into a telescope, by placing the thermo-pile in room of the eye-glass of a reflecting telescope. The heat of the smallest cloud on the verge of the horizon was instantaneously perceptible, and that of a breeze four or five miles off could also be readily perceived.—*Athenæum*, (*London*,) *July*, 1845, p. 700.

35. *Notice in a Letter from London to the Senior Editor, dated Aug.* 30, 1845.

A new line of railroad is being surveyed to connect Bath with Weymouth, and a railroad now cutting for the line from Tunbridge to Tunbridge Wells (in Kent) passes through a fine series of wealden sands and clays. Some of these beds abound in fresh-water shells and crustaceæ, and land and marsh plants. In certain localities the sandstone is full of stems of the Equisetum Lyellii from a few inches to two feet long; and numerous veins of lignite, formed of the carbonized remains of the same species of vegetables. These sands alternate with laminated shales, which are literally full of the crustaceous shells of Cyprides, (Cypris Valdensis,) sprinkled with minute scales of fishes. A small species of the fresh-water shells (Cyclades) so characteristic of the fluviatile deposits, also abounds, together with layers of shelly limestone, also compound of Cyclades. Some of the clays present deeply rippled surfaces; and many of these are studded over with elevated ramose sub-cylindrical casts of vegetable stems, apparently of some of the grasses.

36. *Supplement to Prof. Loomis's Paper, at p.* 266 *of this No.*—The following table shows the average cloudiness of the different months at Nantucket, Mass., deduced from observations taken from April, 1843, to July, 1845, by Miss Maria Mitchell. It was received too late for insertion in its proper connection at page 281 of this No.

Months.	8 A. M.	Noon.	4 P. M.
March, . . .	6·19	6·21	6·08
April, . . .	5·47	5·93	6·09
May, . . .	5·52	5·24	5·35
June, . . .	3·43	3·51	4·24
July, . . .	3·85	3·45	3·64
August, . . .	4·46	4·67	4·15
September, . .	4·79	4·81	4·89
October, . . .	5·36	4·83	4·87
November, . .	5·20	5·64	5·78
December, . .	6·48	6·30	6·05
January, . . .	6·41	5·81	5·35
February, . . .	5·47	5·09	5·21

The results of the foregoing observations, arranged by seasons, are as follows:

	8 A. M.	Noon.	4 P. M.
Spring, . . .	5·73	5·79	5·84
Summer, . . .	3·91	3·88	4·01
Autumn, . . .	5·12	5·09	5·18
Winter, . . .	6·12	5·73	5·54
Year, . . .	5·22	5·12	5·14

37. *Burning Well;* communicated in a letter from F. B. Hough, dated Gustavus, Ohio, Aug. 21, 1845.—The land near the centre of the township of Southington, Trumbull County, Ohio, is low and boggy, although water is not easily found by digging. The soil at the surface is clay, with some sand, and the rock below in this district is a light colored sandstone, which underlies the coal strata of Ohio and western Pennsylvania. No coal has ever been found here below this rock, or north or west of this locality. The nearest beds of workable coal are twenty miles distant.

A pit was sunk for water in this region in June last by Mr. Wannemaker to a depth of twenty four feet, and was continued sixty seven feet seven inches beyond this by boring. It passed through clays in some parts containing selenite, and at bottom reached a coarse sand from which the gas was derived resting upon a rock, probably sandstone. Upon striking into the sand, the carburetted hydrogen gas rushed up by the sides of the augur rod with a shrill whistling noise, upon which the workmen left the well and withdrew the drill. They experienced no difficulty in breathing, and can now descend into the pit without inconvenience. One of the workmen, thinking it might be inflammable gas, lighted a lamp with the design of lowering it, but did not have the opportunity; for no sooner had the match been kindled, than the whole took fire and blazed up to the height of twenty feet, with an explosion that was heard to the distance of three quarters of a mile. Two individuals were scorched and somewhat injured by the explosion. After the first explosion the gas continued to burn at the bottom of the pit for twelve days before it was extinguished. Since this occurrence, which happened on the 17th of July, the gas has continued to issue without abatement, and is frequently set on fire for the amusement of visitors.

The sound of the gas as it issues from the drilled hole resembles the noise of water boiling in a steam engine, and the quantity discharged is sufficient to heat a small steam boiler. Seven years ago the gas from a spring in the vicinity accidentally took fire and burned three or four days. In the summer of 1842, a well was dug in Wethersfield (sixteen miles from the well I have described) to the depth of fifty feet, when carburetted hydrogen was also found. A laborer in attempting to descend with a lamp in the evening for his tools was killed by the explosion.

38. *Particulars of the fall of Meteorites in the Sandwich Islands;* communicated by request, by the Rev. Hiram Bingham, missionary in those Islands, in a letter dated Boston, May 1, 1845.

To Prof. Silliman—On the 27th of September, 1825, a shower of meteoric stones fell, partly in the channel between Molokai and Lanai, and partly between those islands and Oahu, and partly at Honolulu, where I then resided. One explosion was heard at Lahaina, and several in quick succession at Honolulu, eighty miles to the northwest, between the hours of 10 and 11, A. M. The fragment that was seen to pass Lahaina towards Oahu fell in the Molokai Channel, and threw a mass of water into the air, and was said to be followed by a rumbling sound.

The Rev. Mr. Richards of Lahaina mistook the report of the explosion for that of cannon on board of some ship. The explosions which I heard at Honolulu led me at first to suppose they were cannon on board of ships not far distant. But soon after I was satisfied that they were meteoric. Very soon the servants of Kalanimoku, secretary of state, brought me the fragment which they affirmed had just fallen from the sky in our village. This fragment I carefully preserved and brought over, and had the pleasure of presenting to you. A different pleasure from that with which Mr. Richards and myself picked up and forwarded to the Missionary Museum in Pemberton Square, Boston, a cannon ball—one of several which had been fired at our heads.

39. *Remarkable Meteor at Fayetteville, N. C.*—A correspondent of the junior editor of this Journal says, in answer to an inquiry addressed to him concerning this meteor—" September 1st about 2 o'clock, A. M., as I lay in bed, awake, the curtains of my windows being let down, there was a sudden flash of light, which was more durable than that of lightning, and so brilliant that every object for the minute was visible in the room. Supposing it to be lightning, for there had been a heavy thunder storm during the preceding evening, I expected that immediately thunder would follow, and was surprised at the delay. After a space, as I judged of two minutes, there was a tremendous report resembling the continued discharge of heavy artillery. The house seemed to tremble and the windows were shaken in their place. When I rose, nothing was to be seen. The sky was clear, and all was silent. On inquiry in the morning, I learned that a meteor had been seen by several persons passing over the place. The description given by different persons employed as city watchmen is nearly this : The captain of the watch says he was exact in marking the time, and that it was precisely 20 minutes past 2 o'clock, A. M.—that the meteor seemed to rise in the horizon on the east of the town—pass over the town in a direction about N. E. to S. E.—that the light for the moment was as bright as the noon-day sun—and as he thinks, a space of from 5 to 6 minutes intervened between the first appearance of the light and the report. Another watchman gives nearly the same account. The light became extinct as he thinks about five minutes before the report was heard. The captain of the watch says that pieces seemed to fly off from the main body. A countryman, who came to market in the morning, says he was encamped about 7½ miles from town, that he saw the meteor coming in the direction where he was, and thinking that it might strike him, he sprang behind a large pine tree for shelter. I cannot find that any thing was seen or heard of the meteor further than about 35 miles south of this." C.

Fayetteville, N. C., Sept. 16th, 1845.

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