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ART. I.—*Alexander von Humboldt, his early Life, his Education, his Writings, and his Books;* by HENRY STEVENS of Vermont, F.S.A. etc., 4 Trafalgar Square, London.

THE higher the sun the shorter the shadow; even so the greater the eminence of a philosopher the briefer need be his eulogy by the unphilosophical. Nevertheless so exceptional was Humboldt in himself, his early training, his achievements, it may not be deemed out of place here, though perhaps at the expense of wearying the unlearned who need not know so much, or worrying the learned who know it already, to recapitulate a few of the well known points in the life, education, and character of this illustrious man.

If the indifferent reader will run his quick eye over the titles of the seventeen thousand volumes recorded in the Catalogue of his Library he will, no doubt, see at a glance that in very many respects, it is the most extraordinary collection of modern

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[The above article has been contributed to the Journal at our request by Mr. Henry Stevens, a gentleman of well known bibliographical attainments, who purchased the library of Humboldt, not long after his decease, and who has arrived at many interesting conclusions in respect to the distinguished scientist, based chiefly upon the examination of his literary and scientific collections. It was originally written as a preface to a Catalogue of the Library prepared under the direction of Mr. Stevens. Owing to a change in Mr. Stevens's plan respecting its publication, some slight alterations have been made in it, but not in any way to affect the comments upon Humboldt.—EDS.]

scientific books, especially those pertaining to the physical sciences, ever brought together. It is true, many of the common every-day standard works of this class such as 'no library should be without,' are wanting here, particularly the long sets of scientific periodicals, the transactions of learned societies and other equally valuable and bulky books; but when it is remembered that the great philosopher, while in Paris, where for twenty years he was revising and finishing what he had done, and afterwards while at Berlin, where in his old age, in working up his masterpieces of thought, he brought back to the anvil that which he had hammered, always had at his elbow some of the best public and private libraries in France and Germany, as free to him at all times as his own, their absence from his own collection is accounted for. But the reader will observe that an unusually large proportion of Humboldt's books cannot be found in any other single library, public or private, in Europe or America, not excepting even the British Museum, the Imperial Library of Paris, the Royal Library of Berlin, or the Royal Society of London. Indeed it is a matter of fact, that on a careful examination in 1862–3, it was found that the library of the British Museum, was deficient in at least one-third of the titles entered in this catalogue, every one of which was deemed a desirable acquisition. These were mostly privately printed or unusual works. Almost every page of the catalogue contains books important in themselves, which no money can buy in the usual channels of commerce, but which in every tongue were drawn together from all parts of the world, by the irresistible gravitation of Humboldt's name.

About the year 1855 in this country an unfortunate public impression was achieved, for a purpose, and sedulously enforced by high authority, to the effect that the collection of large libraries of scientific and other books was not necessary to the *increase and diffusion of knowledge among men.* "There are two individuals," wrote a distinguished savant to the Committee of Congress, "who may, without qualification, be considered the most prominent scientific men of the nineteenth century—Cuvier and Humboldt. By what means have they given such powerful impulse to science? How have they succeeded not only in increasing the amount of knowledge of their age, but also in founding new branches of science? It is by their own publications and by aiding in the publications of others; by making large collections of specimens and other scientific apparatus, and not by the accumulation of large libraries. Humboldt never owned a book, *not even a copy of his own works*, as I know from his own lips. 'He was too poor,' he once said to me, 'to secure a copy of them'; and all the works he receives constantly from his scientific friends are distributed by him to needy students." The very historical truth was then and is now that the two best scientific private libraries in Europe belonged to Cuvier and Humboldt, the one lining the splendid salons in which the baron held those historic reunions; the other described in this catalogue which contains all the books Humboldt ever wrote, many of them thumbed, worn and annotated.

Humboldt was a fortunate child of nature. A lucky star seems to have presided at his birth. On the third of June, 1769, occurred the rarest and most important phenomenon within the whole range of mathematics and astronomy; an event more favorable of its kind than any that had been observed since the Christian era began, or would again occur for hundreds of years; an event which Rittenhouse in America, Euler in Germany and many other eminent astronomers of other countries were deputed to observe for the benefit of mankind. The last *Transit of Venus,** the great opportunity for determining the sun's parallax, and consequently the dimensions of our planetary system and our globe, was a conjunction of planets coincident with the birth of twelve imperial men of nature, more renowned than the twelve Cæsars. No other single year probably, before or since, ever produced such men as Napoleon, Wellington, Soult and Ney; Brunel, Mehemet Aly, Turner, Sir Thomas Lawrence, Châteaubriand, and Castlereagh; CUVIER and HUMBOLDT; men who upturned the world and set it right again; who revolutionized science, art, politics, states, and the affairs of mankind. Humboldt, in many respects the most gifted of them all, outlived them all.

With his life ended, and became historic, the first grand period of modern science. The times that developed the French Revolution ripened Humboldt, and made conspicuous others, many of them his friends and fellow laborers, among

* *Transits of Venus* are as rare as they are important. They occur in couples, in June and December, about eight years apart, and then not again for several generations. Kepler was aware of the phenomenon and as early as 1604 announced that one would take place in 1761, but young Horrocks of Liverpool with better tables, and additional data, calculated that there would be a *transit* on the 4th of Dec., 1639. He let a friend into his secret, and they two on the day named, for Venus was punctual, were the first ever known to observe it. It was soon calculated that one must have taken place on the 6th of Dec., 1631, and another in June, 1526, and that the next would not occur till the 5th of June, 1761. But of all the transits, past and to come, the climax would be, that of the 3d of June, 1769, when Venus passed across the sun's disc very near the center. The next one, but not visible in this country, will take place five years hence on the 8th of Dec., 1874, which will be a grand one for science, considering the great advance in scientific instruments, but far inferior to the last. If, however, it produces only half a dozen Cæsars it will be a godsend to this rapid century. *Let young folks take note of the date* 1874. Another will occur on the 6th of Dec., 1882, but not again till nearly five quarters of a century later, on the 7th of June, 2004; to be followed eight years after, on the 5th day of June, 2012; to be repeated in Dec., 2117, and so on.

whom may be named LaPlace, Lalande, Gay-Lussac, Kunth, Bonpland, Oltmans, Oersted, Bichat, Delambre, Bessel Berzelius, Davy, Robert Brown, Dalton, Herschel, DeCandolle, Latreille, Valenciennes, Audubon, David d'Angier, Arago, Gauss, Ritter, Müller, Leopold von Buch, Varnhagen von Ense, Compte, Biot, *et al.*, names themselves suggesting discoveries, inventions and unbounded knowledge.

ALEXANDER VON HUMBOLDT was born in Berlin on the 14th of September, 1769, and died there on the 6th of May, 1859, in the ninetieth year of his age. A rapid sketch of his youth and early manhood will serve to show how well he prepared himself, single-handed, to accomplish so much; more even than most of the learned academies of which he was a member, and certainly not less than any of the great Voyages of Discovery, and celebrated Exploring Expeditions conducted at the public expense. The course pursued with him was so peculiar, and contrasts so completely with the usual course of training in the colleges of this country, even in the scientific departments, that no pains have been spared to render this account as complete and exact as possible. Unroll the scrolls of biography and no name will be found a brighter example to stimulate, encourage and direct the youthful student than that of Humboldt.

He was fortunate in his father, Major von Humboldt, who gave him wealth and position; favored in his elder brother William, who gave him the best of companionship, whom he and the world alike loved and honored through a long life; and blessed in his noble mother, to whose virtues, devotion to her boys, energy of purpose, and common sense he owed a right start both in the political world, which he disliked, and in the physical world, which he adored. The earliest tutor chosen by the mother to teach and play with the two boys was Campe the educationist, who among other children's books, edited in German, Robinson Crusoe, a work which no doubt had its early influence in bending the youthful twig. When Alexander was eight years old his father died. The mother and her two boys then lived at Tegel the old homestead a few miles from Berlin. Alexander's constitution was not very strong. In the year 1779 the widow was fortunate enough to secure for their companion and tutor, G. J. Christian Kunth, a youth of twenty, a rare and noble fellow, in whom the mother could and did place implicit confidence. He took charge of the brothers, and became their guide, companion and friend, at the same time being in constant consultation with their mother. How admirably he guided them in their boyish games and studies, and how faithfully he labored for and with them in after life, both the brothers bear ample testimony. The next year, when Alexander was eleven, he heard at Tegel private lectures on botany by Heim. Two years later Kunth used to take the boys to Berlin to pursue their studies with private masters. They studied together, but each was allowed to follow his own bent. Though Alexander differed widely from William in his inclination for some studies, yet both were alike ardent, and each sympathized with the taste of the other. Here Löffler taught them Greek, and young Willdenow, a rising botanist, with perhaps the best herbarium in Europe, instructed them in botany, while Dohn, Engel, Klein and other distinguished professors were engaged by their ever faithful tutor, to give them private lectures in law, politics, philosophy, mathematics, and the physical sciences. Kunth too heard all these lectures, and a little boy of nine, four years younger than Alexander, heard some of them, Leopold von Buch his name.

Thus they passed two years partly at the capitol and partly at Tegel, always under the watchful care of Kunth, and all three under the eye of the mother, with no temporal cares to retard their progress, and no family obscurity to embarrass their position. Two years later Kunth and his charge, late in 1785, took their first leave of the mother for a time, and went to join the University at Frankfort on the Oder, where they resided two years or more, in the family of their Greek professor Löffler, who had removed thither from Berlin. At Easter, 1788, having exhausted the resources of Frankfort and grounded for a higher course, Kunth accompanied the brothers to Göttingen, at that time the most celebrated University of Germany. Here Alexander at the age of eighteen found ample scope for all his aspirations in nature and natural science, and both brothers had more ample opportunities afforded them to follow out the diverse branches of research to which each felt a strong innate tendency.

The University of Göttingen was then at its zenith, with the best selected library of modern books in Europe. Here they met and cemented lasting friendships with those world-renowned Professors, Blumenbach, Eichhorn, Gmelin, Heeren, Heyne and George Forster, all of whom in after life the brothers were never tired of naming with love and gratitude. The wives of Heeren and Foster were the accomplished daughters of Heyne, he of *the* Homer, he of *the* Virgil, who was himself both Professor of languages and librarian of the University. Into this learned family circle the brothers were cordially admitted in the closest terms of intimacy. Alexander soon became the favorite pupil of the great naturalist Blumenbach, and was proud to call himself the scholar of Gmelin.

But it was to George Forster that Alexander never ceased to acknowledge his indebtedness. Forster was then only thirty-four. He had accompanied Capt. Cooke in his second voyage round the world in 1773–1775, with his father J. Reinhold Forster, and in the following year 1777 gave to the world his marvelous book, *Reise nach der Südsee*, which afterwards made a profound impression on the mind of young Humboldt, and was perhaps the first great incitement in him to the scientific study of nature. How rejoiced then must he have been to find at Göttingen, Forster whose voyages he knew by heart, and whom he delighted long after to call 'my celebrated teacher and friend.' 'If I might,' wrote he in *Cosmos* in the late evening of his life, 'be permitted to instance my own experience, and recal to mind the source from whence sprang my early and fixed desire to visit the land of the tropics, I should name George Forster's *Delineations of the South Sea Islands*,' etc.

The same year, 1788, and while enjoying the society of Forster, there appeared another little book which seems to have still further aroused his love of nature and strengthened his resolution, already formed, for great voyages. This was Bernardin de St. Pierre's master work, *Paul and Virginia*, a copy of which he says in *Cosmos* 'accompanied me to the climes whence it took its origin. For many years it was the constant companion of myself and my valued friend and fellow traveler Bonpland, and often in the calm brilliancy of a southern sky, or when in the rainy season the thunder re-echoed, and the lightning gleamed through the forests that skirt the shores of the Orinoco, we felt ourselves penetrated by the marvelous truth with which tropical nature is described, with all its peculiarity of character, in this little book.'

After a residence of nearly two years at Göttingen, studying languages, botany, zoology, geography, chemistry, mathematics, geology, mineralogy, etc., in the spring of 1790, Humboldt joined his friend Forster at Mayence, whither he had removed, and they two set out on a private scientific Exploring Expedition down the Rhine. At that time the great question that devided geologists, had reference to the Plutonian and Neptunian origin of rocks. The Basalt of that noble river was before him, and accoutred as he was he plunged into the controversy with mind impartial and fresh from the university. The result of his investigations appeared the same year in his first book, at the age of twenty, entitled, *Mineralogische Beobachtungen über einige Basalte am Rhein. Braunschweig*, 1790, 12°. It is a very neat little volume arrranged with taste and judgment, and in a scientific point of view is said to be creditable to a much older head. The book was published anonymously and is now but little known, being very scarce. The copy described in the Catalogue (No. 4563), and now belonging to General Frémont, possesses peculiar interest. It bears the author's autograph signature, at the end of the dedication, and was presented to Professor Gmelin in 1790, with an affectionate inscription 'by his scholar, A. von Humboldt.' More than sixty years after, on his eighty-fifth birth-day, this precious little volume was re-presented by Theodor Wagener to the great philosopher, who on the 14th of Sept., 1854, inscribed in it a graceful memento of his youth and of his old age.

From the Rhine the travelers passed through Holland and Belgium, and thence to England, where Forster introduced Humboldt to the President of the Royal Society, Sir Joseph Banks, his fellow voyager fifteen years before with Capt. Cooke round the world. He was warmly received by many of the scientific men of London. At the house of Warren Hastings he was shown some pictures by Hodge representing the shores of the Ganges, which made a lasting impression upon his youthful mind, and still further increased his longing for travel. On returning to Germany he published his book, and then the first great question of his life was asked by his mother. What next? There is some pretty strong evidence that she desired him to take to political life and become a diplomatist or statesman. At all events it was determined that he should enter upon some public employment, and the better to qualify him for this, he went to Hamburgh, and in the winter of 1790–1791 attended the celebrated Commercial Academy of Ebeling, studying business, accounts, trade, banking, and commerce, as much as his ardent love of the physical sciences would permit. But even here, of all places in the world, he was unexpectedly encouraged in his ruling passion. Ebeling became his friend and opened to him the treasures of his own private library, at that time one of the largest collections of voyages and travels with maps and geographical works relating to America, then in Europe. Ebeling was about to go to press with the first volume of his great work on America and hence his mind was full of the subject. That rich collection was afterward purchased by Mr. Thorndike of Boston, and presented to the library of Harvard College, of which to this day it forms a prominent feature.

After a struggle of a few months between business and science, Humboldt's inordinate love of the latter finally triumphed, and in 1791 he turned his back on Ebeling his friend, and commerce his foe, and soon after found himself in Werner's house in Freiberg, with that dear boy for his chum whom he had met at lectures eight years before in Berlin, Leopold von Buch, then a youth of seventeen. Werner, at that time the greatest geologist of the age, was Director of the School of Mines at Freiberg. From sight these two young men became friends for life. More than three score years later, wrote Humboldt, 'That I should be destined—I, an old man of eighty-three—to announce to you, dear Sir Roderick, the saddest news that I could have to convey:' . . . 'Leopold von Buch was taken from us this morning' . . . . 'without him I am desolate.' . . . 'His mind left a track of light wherever it passed.' . . . 'We were together in Italy, in Switzerland, in France,—four months in Saltzburg.' At Freiberg Humboldt devoted himself with humboldtian energy to the study of mining and metallurgy. His mind was ever open and ready for impressions, which it received as surely as wax, and as speedily as photography. No bee could exhaust the wild flowers of the woods quicker than he could extract from his masters all they had to impart. Scarcely a year then sufficed to accomplish his aim at Werner's, whom he left in March, 1792, and returned to his mother at Tegel.

Humboldt had now arrived at the end of his pupilage; and such a pupilage! unparalled in biography. Who before him was ever so favored by fortune, so mentally gifted, so lovingly *led*, and so intellectually prepared, for the brilliant career upon which he was about to enter? Yet he took no royal road to his acquisitions, but that hard paved one open to all, with work, self reliance, energy and love of nature for mile stones. At this early age we find him in scholarship ripe beyond his years, a linguist, an archaeologist, a botanist, a geographer, a geologist, a mineralogist, a metallurgist, a chemist, and an author. His travels for the period had been considerable, and few had so many learned friends. What a contrast to the youthful struggles of the immortal Franklin, and yet these two are perhaps the brightest examples for youth in record. Thus prepared Humboldt was launched into the wide world at the age of twenty-two, burning with an irresistible desire, as he repeatedly tells us in after life, to travel in distant lands unexplored by Europeans.

The next five years, from 1792 to 1797, the young aspirant is tracked with some difficulty through a combination of circumstances well calculated to elevate, strengthen and mature him for the execution of some grand project. Born and educated in central Germany, remote from salt water, with a love of nature ingrain and strengthening with his knowledge, he longed for the sea, as he tells us, and the tropics, and had already resolved, as soon as the opportunity presented itself, to go round the world, and gratify his enthusiasm for the savage beauties of tropical countries guarded by mountains and volcanoes, shaded by primeval forests and watered by vast unexplored rivers; and going or coming, explore that New World where man and his handiworks of ancient and modern civilization had not intervened to dwarf the stupendous display of gigantic nature. All his studies now tended to qualify him for a scientific traveler. As his journey was to be the circle of the globe, so his study was the circle of the sciences. He worked hard and observed closely; and, what in a young observer of nature is of the highest importance, he reduced to order his observations and wrote them out. During his short year with Werner, the parent of the Neptunian theory, he found time to collect and describe the cryptogamous plants he found growing far down in the mines of Freiberg. He made drawings of them, wrote out their natural history in good Latin, and sent his manuscript to Göttingen to his old friend and teacher, Blumenbach, who soon after returned it, edited with his own notes, and backed with the seal of his approbation. The work,* a handsome quarto volume, saw the light the next year, at Berlin, it being his *second* book, at the age of twenty-three. The second part of it, *Aphorisms on the chemical physiology of vegetables,* he found of great use to him in his observations in America.

This same year he accepted an official position under government in order that he might have influence and opportunities the better to pursue his investigations. He became the Superintendent of Mines in Franconia, and during the short two years he held that position, is said to have remodeled the systems of development and management. He inspected every department himself, near and remote, and became both an executive officer and a business man; while at the same time he was a student, an observer, an explorer and an author. His mental activity was perfectly marvelous, and his scientific and literary labors prodigious. He made experiments and contributed many articles both in his own and in the French language, to the chief scientific journals of Germany and France. Humboldt thus early achieved a reputation throughout Europe as a rising naturalist. In 1795 he resigned this official position, which, although favorable to the cultivation of his favorite pursuits, still did not fill his active mind, now more and more thirsting for explorations in the equatorial regions. This passion led him to devour and analyze the relations of voyages and travels to India, America, Africa and the Islands, but generally to regret the want of variety of knowledge in insulated branches of natural history. The great Expeditions of Fleurieu in 1768–69, of Bougainville in 1766–69, of Cooke 1768–1780 were familiar to him as household words, as were also afterward those of Vancouver, La Pérouse and d'Entrecasteaux; but all these, though they gave ample accounts of the oceans, their islands and their coasts, yet left him unsatisfied as to the vast interiors of countries and continents. They developed

* FLORÆ FRIBERGENSIS Specimen Plantas cryptogamicas præsertim subterraneas exhibens. Accedunt Aphorismi ex Doctrina Physiologiæ chemicæ Plantarum. iv Plates, 4°, Berolini, 1793. The *Aphorisms* the next year, 1794, were translated into German by G. Fischer, with additions by J. Hedwig, and a Preface by G. F. Ludwig, and published at Liepzig in 8vo.

marine geography and nautical astronomy, but left comparatively untouched, physical geography, botany, zoology, the relations of the vegetable world, the migrations of the *social* plants, and the geological structure of mountains and volcanoes. All these he found set forth more to his liking in M. de Saussure's scientific explorations of the Alps and Vesuvius, which interested him profoundly and caused him to study carefully both the results and the use of the instruments by which they were attained.

In this same year, 1795, freed from official care, Humboldt traveled much through Germany and visited Vienna, where he renewed his studies in botany and physical geography, studied and traveled with Freiesleben the celebrated geognost, and with von Haften visited northern Italy, but was for political reasons deterred from going to the volcanic regions of Naples and Sicily. At Vienna he became acquainted with the recent discoveries of Galvani which interested him deeply, and henceforth galvanism became one of his special studies, if indeed a mind of such general grasp can attend on specialties. Many months of most useful preparatory study he passed there examining the exotic plants, and enjoying the friendship, of M. de Jacquier and of M. Vander Schott. Already familiar with the experiments of Franklin and others in electricity, he began there his famous experiments in chemistry, galvanism, electricity and other matters pertaining to organic life, which in importance and originality rivalled the celebrated but subsequent investigations of Bichat.

About this time, at the instigation of Baron von Zach, he found time to acquire a practical knowledge of astronomy, surveying, geometry and mathematics, all so essential to travelers, and became familiar with the use of the various scientific instruments for ascertaining latitudes and longitudes, heights and distances, etc. Next, in the winter of 1796–97, we find him at Jena studying anatomy and physiology under Loder. Here he continued his investigations into animal life in connection with chemistry, galvanism and electricity, and especially experimented on the irritability of the muscular fibre, the vital force in animals and plants, and almost hoped that he had found the clue to the phenomena of life. In close connection with these studies he found it necessary to obtain a practical knowledge of zoology, ichthyology and ornithology. All these investigations and experiments, containing the germs of a new science, which, especially in America, is to-day exerting itself with vigor, were embodied in his *third* book* published in Posen in 1797, in two volumes in octavo.

* Versuche über die gereizten Muskel- und Nervenfasern oder Galvanismus, nebst Vermuthungen über den chemischen Process des Lebens in der Thier- und Pflanzen-

Humboldt now began to think seriously of leaving Europe for a long journey, but regretted to do so without first having seen Vesuvius, Stromboli and Etna, to enable him by comparison to form a 'proper judgment of a great number of geological phenomena; especially of the nature of the rocks of trap formation, it became necessary to have examined strictly the phenomena offered by burning volcanoes.' At Jena he revived his friendship with Goethe and Schiller, the one twenty, the other ten, years his senior, both of whom he terrified by his tremendous energy, and inspired with his own love of nature. 'My natural historic studies have been roused from their winter sleep by his presence' wrote Goethe to Schiller; and wrote Schiller to Goethe 'Although the whole family of Humboldt lie ill of the ague they speak only of great journies.' He therefore determined to return to Italy and with his friend Leopold von Buch set out in November, 1797. They spent some time in Vienna, four months in the several cantons of Salzburg and Styria, pursuing to great advantage their geological investigations; but as they were about to pass the Tyrolian Alps the wars of Italy compelled them to turn back, and, to Humboldt's great regret, to abandon the volcanoes. They then proceeded through France home to Berlin.*

The time had now arrived for immediate preparation for his great voyage. But whither go? He was undecided, the impediments of wars and politics being so great it was impossible to determine. However, having buried his mother, and settled his worldly affairs for a long absence, he set out for Paris in 1798. His fame had already preceded him, and he soon made the acquaintance of many savans, and set about earnestly to collect the instruments and all things necessary for a long scientific exploring expedition. The very list of this apparatus filling pages in his *Personal Narrative* is enough to overpower the mind of an unscientific traveller. There were chronometers, telescopes, (achromatic and simple), lunettes, sextants, reflecting and repeating circles, theodolites, artificial horizons, quadrants, compasses, graphometers, dipping and other needles, magnetometers, pendulums, barometers, thermometers, hygrometers, electrometers, cyanometers, eudiometers, phosphoric eudiometers, boiling water meters, thermometrical leads, areometers, compound microscopes, meters, gauges, chains, tubes, vases, evaporators, Leyden vials, galvanic apparatus, etc., not one of each only, but

welt mit Blumenbachs Anmerkungen 2 vols., viii Plates. 8° Posen, 1797–1799. This work was immediately translated into French with the following title: Expériences sur le Galvanisme et en général sur l'irritation des fibres musculaires et nerveuses: trad. de l'allem. [par Gravel] avec des additions par J. F. N. Jadelot, medicin. 8° Paris, 1799.

* About this time he must have prepared his *fourth* and *fifth* books, which were printed at Braunschweig in octavo in 1799, the one *über die chemische Zerlegung des Luftkreises und über einige andere Gegenstände der Naturlehre*, and the other *über die unterirdischen Gasarten und die Mittel ihren Nachtheil zu vermindern.*

in many instances duplicates and even triplicates. Most of the instruments he had already tested in kind in his various travels and explorations the past two years, and had therefore confidence in his own judgment in selecting them.

The first opportunity that presented itself he accepted, though not much to his taste. Lord Bristol asked him to accompany him to Upper Egypt on an archæological exploring expedition of eight months. He accepted this proposal and for some time directed his studies in conformity with this new project; and though it was abandoned in consequence of the temporary insecurity to travelers, he found that the archæological information then acquired proved in Mexico to be of no inconsiderable service to him. Meanwhile he had made the acquaintance in Paris of two young naturalists, Aimè Bonpland of La Rochelle, and Michaux of Versailles, who had been appointed to the proposed Exploring Expedition to be commanded by Captain Baudin, round the world by Cape Horn, skirting South America from the La Plata to Quito and Panama, and thence across the Pacific to New Holland, Van Diemen's Land, Madagascar (the scenes of his friends Paul and Virginia), and so home by the Cape of Good Hope. Though Humboldt had little confidence in Capt. Baudin, he obtained permission to embark with all his instruments, reserving to himself, however, the liberty to leave the expedition whenever he thought proper. For several months he worked with an eye single to this great enterprise, with his whole heart and soul in it, when, on a sudden, news came that war had broken out in Germany and Italy, and Napolean had determined to postpone the expedition indefinitely. The disappointment was cruel, but the knowledge he had gained was not dissipated. His determination now was to quit Europe at once, by engaging in any enterprise that might tend to console him.

He had made the acquaintance of a Swedish Consul, appointed by his government to carry presents to the Dey of Algiers, passing through Paris, who offered to give to Humboldt, if he would accompany him, the advantage of his long acquaintance in that part of Africa, to facilitate him in visiting the Atlas Mountains of Morocco. No mineralogist had yet examined this lofty chain of mountains which rose to the limit of perpetual snow. He jumped at this proposal, and his friend Bonpland jumped with him. The Swedish frigate was to reach Marseilles towards the end of October, 1798, and therefore all three hastened thither. Two long months they waited there, and no frigate came, but finally news reached them that she had met with accidents and could not be expected at Marseilles till spring. Disappointed again, almost disheartened, but not discouraged, they resolved to spend the winter in Spain, and in the spring if possible embark at Carthagena or Cadiz for the East. Their instruments they took with them, leaving only the duplicates at Marseilles to follow. Their object was still to work to the East, to India if possible. They crossed Catalonia, Valencia and Old Castile to Madrid, making on their way many astronomical and geographical observations, and ascertained the inclination of the needle and the intensity of the magnetic forces, the results of which were never published.

Immediately on their arrival in Madrid they had reason to rejoice at the wind that wafted them to Spain. Baron de Forell the Saxon minister, himself a mineralogist, at once interested himself in their behalf, thought they might obtain through the enlightened minister Urquijo, permission to visit the interior of Spanish America. The friends hesitated not a moment to adopt this suggestion. In March, 1799, Humboldt was presented at Court, and himself presented to the King a memoir on the motives which led him to undertake a voyage to the new continent and the Phillippine Islands. The result was without delay two passports for himself and Bonpland, one from the Secretary of State, and the other from the Council of the Indies. That he might not be obstructed by narrow-minded viceroys, priests or remote officials of church or state, he had it set down plainly in the bond that he was authorized to make free use of his instruments of all kinds, might make astronomical observations, measure heights and weigh mountains, examine the soil, explore rivers, inspect mines, and in short execute all operations deemed useful for the progress of the sciences, throughout the whole of the Spanish dominions. No passport from the Spanish government, before or probably since, was ever so liberal. Thus after many disappointments, and changes of plans, consequent upon the wars and the generally unsettled state of the political world, Humboldt had great reason to congratulate himself, as indeed the whole world with all the sciences at this day has to congratulate itself, that he at last drifted into Spain, all the tougher, the wiser and the better for his many disappointments. The travelers proceeded immediately to Coruña, secured a passage in the Sloop Pizarro, a companion of the monthly packet boat, and in June, 1799, embarked their instruments and impedimenta. But the port of Coruña was at that time blockaded by an English squadron. However, under the protection of a friendly storm which obliged the English to stand out to sea, and the cover of a dark night, the Pizarro ran the blockade, and on the sixteenth of July, landed at Cumana in Venezuela, within sight of that beautiful Paria which Columbus discovered in April, 1498, and believed to be Paradise, whence our first parents were expelled. Thus three hundred years after Columbus, an Italian, had sailed from a port in Old Spain to discover a new world, Humboldt, a German, and his friend Bonpland, a Frenchman, availed themselves of the same alien courtesy to go and discover what it contained.

[To be continued.]

ART. I*.—*Livingstone's African Explorations.* Despatch from Dr. Livingstone to the Earl of Clarendon*, dated 'near Lake Bangweolo, South Central Africa, July 8th, 1868.'

My Lord—When I had the honor of writing to you in February, 1867, I had the impression that I was then on the watershed between the Zambesi and either the Congo or the Nile. More extended observation has since convinced me of the essential correctness of that impression; and from what I have seen, together with what I have learned from intelligent natives, I think that I may safely assert that the chief sources of the Nile, arise between 10° and 12° south latitude, or nearly in the position assigned to them by Ptolemy, whose River Rhaptus is probably the Rovuma. Aware that others have been mistaken, and laying no claim to infallibility, I do not yet speak very positively, particularly of the parts west and northwest of Tanganyika, because these have not yet come under my observation; but if your Lordship will read the following short sketch of my discoveries, you will perceive that the springs of the Nile have hitherto been searched for very much too far to the north. They rise some 400 miles south of the most southerly portion of the Victoria Nyanza, and, indeed, south of all the lakes except Bangweolo.

Leaving the valley of the Loangwa, which enters the Zambesi at Zumbo, we climbed up what seemed to be a great mountain mass, but it turned out to be only the southern edge of an elevated region, which is from 3000 to 6000 feet above the level of the sea. This upland may roughly be said to cover a space south of Lake Tanganyika, of some 350 miles square. It is generally covered with dense or open forest, has an undulating, sometimes hilly, surface; a rich soil; is well watered by numerous rivulets, and, for Africa, is cold. It slopes toward the north and west, but I have found no part of it under 3000 feet of altitude. The country of Usango, situated east of the space indicated, is also an upland, and affords pasturage to the immense herds of cattle of the Basango, a remarkably light colored race, very friendly to strangers. Usango forms the eastern side of a great but still elevated valley. The other or western side is formed by what are called the Kone Mountains, beyond the copper mines of Katanga. Still further west, and beyond the Kone range or plateau, our old acquaintance the Zambesi, under the name of Jambaji, is said to rise. The southern end of the great valley inclosed between Usango and the Kone range is between 11° and 12° south. It was rarely possible there to see a star, but accidentally awaking one morning between 2 and 3 o'clock, I found one which showed latitude 11° 56′ south, and we were then fairly on the upland. Next day we passed two rivulets running north. As we advanced, brooks, evidently perennial, became numerous. Some went eastward to fall into the Loangwa; others went northwest to join the River Chambeze. Misled by a map calling this river in an off-hand manner 'Zambezi, eastern branch,' I took it to be the southern river of that name; but the Chambeze, with all its branches, flows from the eastern side into the center of the great upland valley mentioned, which is probably the valley of the Nile. It is an interesting river, as helping to form three lakes, and changing its name three times in the 500 or 600 miles of its course. It was first crossed by the Portuguese, who always inquired for ivory and slaves, and heard of nothing else. A person who collected all, even the hearsay geography of the Portuguese, knew so little actually of the country that he put a large river here running 3000 feet up-hill, and called it New Zambesi.

I crossed the Chambeze in 10° 34′ south, and several of its confluents south and north, quite as large as the Isis at Oxford, but running faster, and having hippopotami in them. I mention these animals because in navigating the ambezi I could always steer the steamer boldly to where they lay, sure of

* From the Minutes of the Royal Geographical Soc., for the Meeting of Nov. 8th

finding not less than 8 feet of water. The Chambeze runs into Lake Bangweolo, and on coming out of it assumes the name Luapula. The Luapula flows down north past the town of Cazembe, and 12 miles below it enters Lake Moero. On leaving Moero at its northern end by a rent in the mountains of Rua, it takes the name Lualaba, and passing on N.N.W., forms Ulenge in the country west of Tanganyika. I have seen it only where it leaves Moero, and where it comes out of the crack in the mountains of Rua, but am quite satisfied that even before it receives the river Sofunso from Marungu, and the Soburi from the Baloba country, it is quite sufficient to form Ulenge, whether that is a lake with many islands, as some assert, or a sort of Punjaub —a division into several branches, as is maintained by others. These branches are all gathered up by the Lufira—a large river, which by many confluents drains the western side of the great valley. I have not seen the Lufira, but pointed out west of 11° south, it is there asserted always to require canoes. This is purely native information. Some intelligent men assert that when the Lufira takes up the water of Ulenge, it flows N.N.W., into Lake Chowambe, which I conjecture to be that discovered by Mr. Baker. Others think that it goes into Lake Tanganyika at Uvira, and still passes northward into Chowambe by a river named Loanda. These are the parts regarding which I suspend my judgment. If I am in error there and live through it, I shall correct myself. My opinion at present is if the large amount of water I have seen going north does not flow past Tanganyika on the west, it must have an exit from the Lake, and in all likelihood by the Loanda.

Looking back again to the upland, it is well divided into districts, Lobisa, Lobemba, Ubengu, Itawa, Lopere, Kabuire, Marungu, Lunda or Londa, and Rua; the people are known by the initial 'Ba' instead of the initial 'Lo' or 'U' for country. The Arabs soften 'Ba' into 'Wa, in accordance with their Suaheli dialect; the natives never do. On the northern slope of the upland, and on the 2d of April, 1867, I discovered Lake Liemba; it lies in a hollow, with precipitous sides 2000 feet down; it is extremely beautiful, sides, top, and bottom being covered with trees and other vegetation. Elephants, buffaloes, and antelopes feed on the steep slopes, while hippopotami, crocodiles, and fish swarm in the waters. Guns being unknown, the elephants, unless sometimes deceived into a pitfall, have it all their own way. It is as perfect a natural paradise as Xenophon could have desired. On two rocky islands men till the land, rear goats, and catch fish; the villages ashore are embowered in the palm-oil palms of the West Coast of Africa. Four considerable streams flow into Liemba, and a number of brooks (*Scotticè*, "trout *burns*"), from 12 to 15 feet broad, leap down the steep bright red clay schist rocks, and form splendid cascades, that made the dullest of my attendants pause and remark with wonder. I measured one of the streams, the Lofu, 50 miles from its confluence, and found it at a ford 294 feet, say a 100 yards broad, thigh and waist deep and flowing fast over hardened sandstone flag in September—the last rain had fallen on the 12th of May. Elsewhere the Lofu requires canoes. The Louzua drives a large body of smooth water into Liemba, bearing on its surface duckweed and grassy islands; this body of water was 10 fathoms deep. Another of the four streams is said to be larger than the Lofu, but an over-officious headman prevented my seeing more of it and another than their mouths. The lake is not large, from 18 to 20 miles broad, and from 35 to 40 long; it goes off N N.W. in a river-like prolongation two miles wide, it is said, to Tanganyika: I would have set it down as an arm of that lake, but that its surface is 2800 feet above the level of the sea, while Speke makes that 1844 feet only. I tried to follow the river-like portion, but was prevented by a war which had broken out between the Chief of Itawa and a party of ivory traders from Zanzibar. I then set off to go 150 miles south, then west, till past the disturbed district, and explore the west of Tanganyika; but on going 80 miles I found the Arab party, showed them a letter from the Sultan of Zanzibar, which I owe to the kind offices of his Excellency Sir Bartle Frere, Governor of Bombay and was at once supplied with provisions, cloth, and beads; they showed the greatest kindness and anxiety for my safety and success. The heads of the party readily perceived that a continuance of hostilities meant shutting up the ivory market, but the peace-making was a tedious process, requiring 3½ months. I was glad to see the mode of ivory and slave-trading of these men, it formed such a perfect contrast to that of the ruffians from Kilwa, and to the ways of the atrocious Portuguese from Tette, who were connived at in their murders by the Governor D'Almeida.

After peace was made I visited Msama, the chief of Itawa; and, having left the Arabs, went on to Lake Moero, which I reached on the 8th September, 1867. In the northern part Moero is from 20 to 33 miles broad. Further south it is at least 60 miles wide, and it is 50 miles long. Ranges of tree-covered mountains flank it on both sides, but at the broad part the western mountains dwindled out of sight. Passing up the eastern side of Moero we came to Cazembe, whose predecessors have been three times visited by Portuguese. His town stands on the northeast bank of the lakelet Mofwe; this is from two to three miles broad and nearly four long. It has several low, reedy islets, and yields plenty of fish—a species of perch. It is not connected with either the Luapula or Moero. I was forty days at Cazembe's, and might then have gone on to Bangweolo, which is larger than either of the other lakes; but the rains had set in, and this lake was reported to be very unhealthy. Not having a grain of any kind of medicine, and, as fever, without treatment, produced very disagreeable symptoms, I thought that it would be unwise to venture where swelled thyroid gland, known among us as Derbyshire-neck, and elephantiasis (scroti) prevail. I then went north for Ujiji, where I have goods, and, I hope, letters; for I have heard nothing from the world for more than two years: but when I got within 13 days of Tanganyika, I was brought to a stand-still by the superabundance of water in the country in front. A native party came through, and described the country as inundated so as often to be thigh and waist-deep, with dry sleeping places difficult to find. This flood lasts till May or June. At last I became so tired of inactivity that I doubled back on my course to Cazembe.

To give an idea of the inundation which, in a small way, enacts the part of the Nile lower down, I had to cross two rivulets which flow into the north end of Lake Moero; one was 30, the other 40 yards broad, crossed by bridges; one had a quarter, the other half a mile of flood on each side. Moreover, one, the Luao, had covered a plain abreast of Moero, so that the water on a great part reached from the knees to the upper part of the chest. The plain was of black mud, with grass higher than our heads. We had to follow the path which, in places, the feet of passengers had worn into deep ruts. Into these we every now and then plunged and fell, over the ancles in soft mud, while hundreds of bubbles rushed up, and, bursting, emitted a frightful odor. We had four hours of this wading and plunging—the last mile was the worst; and right glad we were to get out of it to the sandy beach of Moero and bathe in the clear tepid waters. In going up the bank of the lake we first of all forded four torrents, thigh deep; then a river 80 yards wide, with 300 yards of flood on its west bank, so deep we had to keep to the canoes till within 50 yards of the higher ground; then four brooks, from 5 to 15 yards broad. One of them, the Chungu, possesses a somewhat melancoholy interest, as that on which poor Dr. Lacerda died. He was the only Portuguese visitor who had any scientific education, and his latitude of Cazembe's town on the Chungu being 50 miles wrong, probably reveals that his mind was clouded with fever when he last observed, and any one who knows what that implies will look on his error with compassion. The Chungu went high on the chest, and one had to walk on tiptoe to avoid swimming. As I crossed all these brooks at both high and low water, I observed the difference to be from 15 to 18 inches, and from all the perennial streams the flood is a clear water. * * * * * * * * * * *

ART. II.—*On the relation between the Intensity of Light produced from the combustion of Illuminating Gas and the volume of Gas consumed;* by B. SILLIMAN.*

(Read at the Salem meeting of the Am. Assoc. for Adv. of Science, Aug. 1869.)

IN photometric observations made to determine the illuminating power or intensity of street gas, it is the practice of observers to compute their observations upon the assumed standard of five cubic feet of gas, consumed for one hour, and in the constantly occurring case, of a variation from this standard, whether in the volume of the gas consumed or in the weight of spermaceti burned, the observed data are computed by the "rule of three," up or down, to the stated terms. The standard spermaceti candle is assumed to consume 120 grains of sperm in one hour, a rate which is rarely found exactly in actual experience.

For example, a given gas, too rich to burn in a standard argand burner at the rate of five cubic feet per hour without smoking, is consumed at the rate of 3½ cubic feet to the hour, with an observed effect of 20 candles power. This result, previously corrected by the same rule for the sperm consumed, is then brought to the standard of five cubic feet by the ratio $3{\cdot}5 : 20 = 5 : 28{\cdot}57$

The candle power of the gas is therefore stated as 28·57 candles, and this result has been universally accepted as a true expression of the intensity of the gas in question, or the relative value of the two consumptions.

In common with other observers, I have long suspected that this mode of computation was seriously in error, as an expression of the true intensity of illuminating flames, and that there were other conditions besides the volume of gas or weight of sperm consumed which must influence, and greatly modify the results. As most of these conditions are considered somewhat at length in a paper on "*Flame Temperatures,*" prepared chiefly from researches conducted by Prof. Wurtz and myself, and presented at the Salem Meeting of the Association, they need not be discussed in this connection.

The results of many trials, made with the purpose of determining the value of these photometric ratios, indicate clearly that the true ratio of increase in intensity in illuminating flames is, within certain limits, expressed by the following theorem, viz :—

* The main points of this paper were made the subject of a verbal communication to the Conn. Academy of Arts and Sciences at their session, June 17th, 1869.

The intensity of gas flames, i. e., *illuminating power, increases* (within the ordinary limits of consumption) *as the square of the volume of the gas consumed.*

As the first experimental demonstration of this theorem was made by Mr. William Farmer, the photometric observer at the Manhattan Gas Co's. works in New York, I propose to speak of it as "Farmer's theorem." I am also indebted to Mr. Farmer and to Mr. Sabbaton, the well known and courteous Engineer of the Manhattan Gas Light Company, for the free use of their experimental data and the permission to employ them in illustration of Farmer's theorem.

The fundamental importance of this new mode of computation will at once appear, if, assuming it for the sake of illustration to be true, we apply it to the case already given above, which then becomes—

$$3{\cdot}5^2 : 20 = 5^2 : 40,$$

showing an increase of forty per cent over the old rule of correction. Let us see how far this theorem is sustained by the test of experiment.

Experiment 1st.—Two similar gas flames, one at each end of the photometer bar, were made to give exactly the same intensity of illumination. This was accomplished of course by placing the Bunsen disc midway between the two burners, and regulating the combustion until the disc was perfectly neutral ; the consumption being noted equal by two wet gas meters under the same pressure. The screen was then moved upon the bar to a point just four times as far from one flame as it was from the other, i. e., the bar being 100 inches, the screen stood at 80, i. e., as 1 : 4. The light from the distant burner was then increased until the disc again showed an equality of illumination. On reading the rate of the gas consumed by the two burners respectively, one gave 3·66 cubic feet and the other 7·32 cubic feet, or exactly double, or in other words, the lights were as the squares of the volumes of gas consumed, thus : $3{\cdot}66^2 : 7{\cdot}32^2 = 1 : 4.$

By the old rule the intensity would have been estimated directly as the volume of the gas consumed, thus :

$$3{\cdot}66 : 7{\cdot}32 = 1 : 2.$$

Experiment 2d.—The following results were obtained with the use of a standard argand burner. The readings of the index meter, the gas consumed in cubic feet, and the ratio of the lights produced, are given in three columns, viz :—

Index,	·0550	=	3·30 feet.	=	1	light.
"	·0725	=	4·35 "	=	2·1	"
"	·0856	=	5·13 "	=	3·2	"
"	·0926	=	5·55 "	=	4·	"

In this series the lights increase in considerably higher ratio than is required by Farmer's theorem, which demands 6·60 cubic feet, corresponding to a four-fold consumption, while the actual consumption was 1·05 cubic feet less than the quantity required by the theorem.

Experiment 3d.—The following series was obtained by another argand burner.

Index,	·062	=	3·72 cub. feet.		=	1 light.	
"	·0814	=	4·88	"	=	2	"
"	·1000	=	6·00	"	=	3	"
"	.1203	=	7·219	"	=	4	"

In this series the ratio is more nearly in accordance with the demands of the theorem, the intensity being still a little in excess of the squares of consumption ($3·72 \times 2 = 7·44$ in place of 7·219).

The gas employed in these comparisons had a candle power of about 14 candles.

Experiment 4th.—Results obtained by a comparison of fish-tail burners, ratio as 4 and 9 feet respectively.

A.	Index,	·0750	=	4·500	cub. feet.	=	1 light.	
B.	"	·1586	=	9·519	"	=	4	"

In this comparison the ratio falls but little short of the demands of the theorem.

Experiment 5th.—Comparison of fish-tail burners.

A.	Index,	·086	=	5·16 feet.	=	1·85
B.	"	·1677	=	10·06 "	=	4·

In this trial the departure from the requirements of the theorem is considerably greater than in any of the preceding experiments. But it appears that from some cause the ratio of the squares does not hold with gas of the power used in these trials (14 candles), where the consumption rises above 9 or falls much below 3 cubic feet. This is undoubtedly connected with the well recognized fact, that there is for each gas a kind of burner and a volume of gas better calculated than any other to develop its maximum intensity.

Experiment 6th.—This series was designed by Mr. Farmer to test by a direct comparison the value of the new as contrasted with the old method of correction. Both trials were made upon the same gas, the second observation following immediately after the first and with the same candle, and therefore should give about the same candle power.

1st *Trial.*—Consumption	of sperm,	32·7 grains.
"	of gas,	5·004 cubic feet.
Mean candle power (15 observations),		13·93 candles.

2d Trial.—Consumption of sperm,		32·2 grains.
" "	gas,	4·58 cubic feet.
Mean candle power of 15 observations,		11·8 candles.

The above data calculated by Farmer's Theorem.

5·004 cubic feet,	and	32·7	grains	give	15·15	candles.
4·58	"	" 32·2	"	"	15·09	"
				Difference,	·06	"

Calculated by the old rule.

5·004 cubic feet	and	32·7	grains	give	15·16	candles
4·58	"	" 32·2	"	"	13·82	
				Difference	1·34	"

It is obvious from the study of these results, that within the limits named the increase of intensity in gas flames, whether naked or argand, is at a ratio certainly as great as the squares of the volumes of gas consumed; and hence it follows that all the photometric determinations, which have been obtained by computation from volumes greater or less than the assumed standard of five cubic feet per hour, in the simple ratio of the volumes consumed must be considered as *absolutely worthless*, provided the theorem of Farmer here announced is confirmed.

It is evident also that this theorem applies with equal force to the weight of sperm consumed by the standard candle as to the volumes of the gas burned in equal times.

With a view to test the theorem of Farmer, I at once sought to apply it to the case of certain observations I had made upon very rich gas obtained from cannel and other rich coals. The photometric power of these gases had been measured in the usual way heretofore practiced by gas engineers, by burning a less quantity than five cubic feet in the standard argand and then computing up to a standard of five cubic feet by direct ratio. The results of this comparison appear to go far to confirm Farmer's theorem.

Peytona Gas.—This gas was made from a coal of West Virginia, known as Peytona Cannel Coal. It was much too rich to permit the flow of five cubic feet from the 15 hole argand burner, with a perfect combustion. The gas was therefore reduced by mixture with a measured volume of street gas of known value, and the illuminating power of the mixture having been carefully determined, the value of the Peytona gas alone was readily calculated and fixed at 42·79 candles. The following trials exhibit the result obtained by burning smaller volumes of Peytona gas, and the values obtained by the two methods of calculation.

No. 1 Argand burner	consuming	5 cubic feet	per hour,	mixed gas=	42·79 candles
2 "	"	3.24 "	"	"	18·95 "
3 "	"	3·48 "	"	"	20·94 "

Here No. 1 represents very nearly the true illuminating power of the gas, and may be assumed as a fair criterion of the law under consideration.

By Farmer's Theorem.

No. 2 becomes $3.24^2 : 18{\cdot}95 = 5^2 : 45{\cdot}12$ candles.
3 " $3{\cdot}48^2 : 20{\cdot}94 = 5^2 : 43{\cdot}22$ "

By direct ratio (old rule).

No. 2 becomes $3{\cdot}24 : 18{\cdot}95 = 5 : 29{\cdot}24$ candles.
3 " $3{\cdot}48 : 20{\cdot}94 = 5 : 30{\cdot}09$ "

By this it appears that by the old rule, assuming the true candle power of the gas to be 42·79 candles, the two observations Nos. 2 and 3 are in error by about 30 per cent, while by Farmer's theorem the error is reduced to 3 per cent, the former being too small and the latter too large.

Albert Gas.—The well known *Albertite* of New Brunswick furnishes a gas of remarkable richness. Its true candle power can be measured only by diluting largely with street gas of known value, and calculating it from the determined intensity of the mixture. In this way the gas from Albertite is shown to have an intensity equal to 70·38 candles. The following results were obtained by consuming different volumes in the burners named.

No. 1 argand burner	consuming	5 cubic feet	= 70·38 candles.
2 " "	"	2·25 "	= 16·39 "
3 'Scotch tip' "	"	3· "	= 25·25 "

By Farmer's Theorem.

No. 2 becomes $2{\cdot}5^2 : 16{\cdot}39 = 5^2 : 65{\cdot}56$ candles.
3 " $3^2 : 25{\cdot}25 = 5^2 : 70{\cdot}14$ "

By simple ratio.

No. 2 becomes $2{\cdot}5 : 16{\cdot}39 = 5 : 32{\cdot}78$ candles.
" 3 " $3 : 25{\cdot}25 = 5 : 42{\cdot}08$ "

The differences from the assumed standard of 70·38 candles are as follows :

By the old rule,	No. 2	falls short	37·6	candles or	115 pr. ct.
" Farmer's theorem,	"	"	4·72	"	7·1 "
" the old rule,	No. 3	"	28·30	"	67·25 "
" Farmer's theorem,	"	"	0·24	"	0·34 "

It will be observed that No. 2 in this series represents a consumption considerably below the minimum which in most cases experiment has shown to be the limit of the proposed theorem, namely, 3 cubic feet, while No. 3, which represents exactly this limit, brings the result within the range of experimental error—it being impossible to make two series of 15 photometric observations which will accord more closely than these.

Wollongong Gas.—This gas was obtained from *wollongonite*, a new carbohydrogen described by me in a late number of this Journal (July, 1869), as coming from Australia. Its illuminating power was determined by mixing 10 per cent of the gas with 90 per cent of street gas. But this mixture was still too rich to burn 5 cubic feet in the Argand standard without smoking, and even when burned at this rate in a fish-tail burner the flame was somewhat smoky and inclined to "tail off." I have therefore little doubt that its true candle power is more nearly 142 candles than to 132 as stated in the article referred to. We quote, however, the observations made as follows:

1 fish-tail burner consuming	5	cubic feet	gave	132·94	candle power.
2 " "	1·5	"	"	12·89	"

Computing the second observation we have:

By Farmer's theorem	for No. 2	143·22	candle	power
" direct ratio	" "	42·96	"	"

This is an extreme case in which the volume of gas consumed in the second observation is far too low, but it is clear that by the old rule the result coming from the consumption of so small a volume of gas is perfectly worthless, while by Farmer's theorem the difference of 10·28 candles is within 7·7 per cent, while if the true intensity of this remarkable gas is placed, as there is good reason to believe it should be, at 142 candles, the agreement in the two observations is absolute.

Every photometric observer can confirm the results here given by reference to his own records of former observations, or by direct experiment designed to test the accuracy of the theorem here announced.

In Sugg's "Gas Manipulation" (London, 1867), page 64, is a tabular statement of the results of an experiment designed to illustrate the unfitness of the "Birmingham" burner, (a special form of argand) to develop the highest intensity of which a gas of 14 candle power is capable when it is used upon any other standard than that of a consumption of five cubic feet per hour. By this statement the burner in question produced from five cubic feet of gas exactly 15 candle power. But when reduced to 4·5 cubic feet consumption the candle power when "corrected to the standard quality of gas by proportion," was only 11·93 candles. The values of the 'correction' referred to can only be conjectured, but assuming that the observation made the uncorrected rendering 11·32 candles (a very probable quantity) we find that the law of the squares of consumption then makes the ratio as follows:—

$$4{\cdot}5^2 : 11{\cdot}32 = 5^2 : 14,$$

a result which in view of the facts before given cannot be regarded as accidental. The theorem applied to this case as it stands reported (including the correction) gives for the value of the fourth term of the ratio 14·7 candles.

I have endeavored to apply this theorem to some of the results recorded in the well known researches of Messrs. Audouin and Bérard, but I find these results stated in a manner which renders it difficult to fix clearly the terms of comparison. I venture, however, to append a few comparisons drawn from two of the tabular records of experiments with butterfly or bat's wing burners of the "fifth series" which so far as they go lend confirmation to the views here presented.

Burner of the fifth series—slit $\frac{1}{85}$ inch wide.

Consumption of the Burners under trial.	Consumption of the Bengel Argand standard burner without cone; 8 in. chimney.	Comparative intensities. The Bengle burner=100.	Intensities by law of the squares of consumption.	Pressures.
Cubic feet.	Cubic feet.			
3·1079	3·6024	50	103	·23622
2·4015	3·5318	40	90·9	·19685
2·0131	3·6024	30	96·	·11811
Burners of same series—slit $\frac{1}{63}$ inch wide.				
3·9555	3·6730	80	92·6	·078474
3·1786	3·6730	60	80·7	·07480
2·6487	3·6730	50	96·7	·07480
2·3309	3·6730	40	97·5	·03937
1·5186	3·6730	20	115·6	·01968

The comparison of their results by this theorem, which gives reasonably exact results for consumptions which are not greater than that of the standard Bengle burner employed by them, fails when the consumptions become greater than that of the standard.

A comparison of the foregoing results will show that the coincidences with the requirements of the theorem of Farmer are, within the limits assigned, too numerous, and too closely accordant, to be considered as otherwise than pointing clearly to its general truth. A rigorous demonstration cannot be expected, as there are too many variable functions of unknown value involved in the best methods at present known for photometric measurements to permit more than an approximate proof of its general accuracy. Every photometric observer must recognize its importance and the necessity in his observations of bringing the consumptions of gas and sperm to the agreed standard.

To the consumer of gas the evident inference from the data here presented is that, where it is important to obtain a maximum of economical effect from the consumption of a given volume of illuminating gas, this result is best obtained by the use of burners of ample flow.

Where a moderate light of equal diffusion is required over a large space, as in public rooms, it may be expedient to use numerous small jets; but when the maximum intensity obtainable from a given volume of illuminating gas is desired, intensity burners of large consumption are plainly indicated.

In the discussion following this paper, Mr. F. Stimpson, State Inspector of gas for Massachusetts, brought forward some results of observations he had made upon Farmer's theorem (having been in correspondence with Prof. Silliman on the subject), and considered them in comparison with those herewith given. His conclusion was that while in many cases the theorem was closely applicable, in others it was not so. Mr. Stimpson's discussion of the matter will very likely appear in an early number of this Journal.

Art. III.—*Principles of Molecular and Cosmical Physics*; by Prof. W. A. Norton.

In a memoir on Molecular Physics, published in 1864–66, in this Journal, and republished in the London Philosophical Magazine, I showed that, by the introduction of a new hypothesis not in itself improbable, the principle of gravitation might be explained. I now find that no additional hypothesis is necessary but that this principle is essentially involved in one of the fundamental principles of the general theory; viz., that of the *interception of force by matter*. This fundamental principle was brought out in treating of the subject of the electric condition of molecules, and formed an essential element in the special theory of electricity developed in the memoir. This interception was regarded as no arbitrary assumption, but as a necessary consequence of the fact that a certain portion of the propagated force is instantaneously expended in imparting motion to the molecule, or atom, which it encounters, and is therefore abstracted from this force. In every instance of a propagated force this conclusion is inevitable. Now I find that if we admit that the primary forces of nature are propagated forces, that is, do not act instantaneously at all distances, the principle of universal gravitation, as well as the doctrine of the molecular forces and agencies set forth in my paper, may be directly deduced from *a single force of repulsion exerted by every primary atom upon every other atom.*

Admitted Principles.—It is now universally conceded: (1st,) that matter exists in at least two different fundamental forms, or conditions, viz: that of universal or luminiferous ether which pervades all space, and that of ordinary matter directly recognizable by our senses.

(2d.) That all masses of matter of sensible extent are made up of distinct atoms.

(3d.) That every atom is essentially inert or incapable of itself of altering its own state, whether of rest or motion; and that in every act of motion, or change of motion of an atom, an amount of force is expended proportionate to the mass of the atom and the velocity, or change of velocity, produced in the direction in which the force acts.

It is also the general conception with physicists, that every atom has a definite form, and a definite size dependent upon the quantity of matter which it contains, and it will serve to fix our ideas to adopt this conception; at the same time it should be understood that in order to arrive at our conclusions the only essential supposition to be made, with regard to the state of an atom, is that it occupies a certain space, proportionate to its quantity of matter, in such a manner as to receive and intercept a certain portion of the force propagated along every line, or a number of lines proportional to its mass, traversing this space.

Cosmical Force of Repulsion.—The fundamental notion of the propagation of force involves with it the conception that the force acts, or is transmitted in a series of recurring impulses. We may also assume that, like all known propagated actions, the force varies according to the law of inverse squares. In fact, if the impulses are transmitted along definite lines, and the atom occupies, as a cause of interception, a definite space, it is obvious that this law must of necessity hold good; or, if they are propagated by the intervention of wave pulses in a more subtile ether, whether the atom be regarded as a mere point or of definite size, so be that it has a definite degree of inertia, the same law should obtain. Now, let us leave out of view, for the present, all the bodies of ordinary matter in existence, and confine our attention to the luminiferous ether uniformly disseminated through space. Every atom of this ether exercises a repulsive action upon every other atom of the same at all distances; and this action consists in a series of impulses perpetually renewed, at an immensely more rapid rate, we must suppose, than those of light or radiant heat. Each effective impulse is but an excessively minute fraction of each individual impulse propagated in the force; and this is expended in giving motion, or virtual motion to the atom. That is, as in all known instances of propagated action, each impulse produces its effect, in the shape of velocity instantaneously imparted, and is expended in so doing, just as if no other impulse or series of impulses were in operation. Since the ether is uniformly disseminated, each atom must be subjected, in an appreciable interval of time, to the same amount of force transmitted from every direction, and therefore cannot experience any sensible displacement. But, although no sensible progressive motion of the ethereal atoms can result, under the circumstances supposed, still it is to be observed that the united effective impulses that come into operation upon the atom in any minute interval of time, *from any one direction*, must be enormously great in comparison with the force of repulsion subsisting between two contiguous atoms of the ether: and this latter force must be vastly greater than the elastic force of the ether called into play in the propagation of a wave of light or heat; since this elastic force results from a slight inequality in the repulsive actions of the contiguous atoms on different sides, attendant upon a slight relative displacement of the atoms. It is, as I conceive, by the coming into operation under certain circumstances, of a portion of this vast cosmical, ethereal force, received from definite directions, that the known effective forces of nature are brought into play.

Immediate consequences of the Interception of the Cosmical Force.—Universal Gravitation.—Let us next conceive that a single atom of ordinary matter is posited at a certain point in the universal sea of ether, and consider what forces would be brought into operation by its interceptive action. In the first place it is obvious that the entire force transmitted from all the ethereal atoms lying on any line intersecting the atom supposed, will be partially intercepted in passing the atom, and that the residual force propagated on will be of less intensity than the force coming toward it in a directly opposite direction. If then any point in space be taken, at any distance from this atom, and right lines be conceived passing through this point and the various points of the atom, and extending indefinitely in both directions, they will form a cone circumscribing the atom and having the point supposed for a vertex; and the force transmitted to the point along every line within the surface of this cone that encounters the supposed atom of ordinary matter, will be less than that received in the directly opposite direction. Accordingly there will be a greater amount of repulsive force transmitted through the vertex of the cone, from the ethereal atoms lying within the outer nappe or indefinite portion of the cone, than from those lying within the other nappe which circumscribes the atom of ordinary matter. The excess will operate as an effective force to urge any atom that may be posited at the vertex toward the ordinary atom. It is obvious that except at minute distances, this effective force would vary inversely as the square of the distance.

All this being understood, let us consider what will be the result with regard to the ether in the immediate vicinity of the supposed atom of ordinary matter. It is plain that each ethereal atom so situated will be urged toward the atom considered, until the effective force directed inward is neutralized by the outward repulsion of the ordinary atom and the increased repulsion of the ethereal atoms lying nearer to this. The ultimate result then would be the condensation of an ethereal atmosphere around the atom of ordinary matter, just as if this exerted a direct attractive action upon the adjacent ether. Now what will be the effect of the supposed atom (a), and its condensed atmosphere of ether, upon any other atom (b)? In the first place the entire interception of the cosmical repulsion produced by a and its atmosphere would give rise to a gravitating tendency of b toward a. But a and its atmosphere exert a direct repulsive action upon b. This direct force of repulsion is the sum of all the repulsive impulses exerted by a and the atoms of its atmosphere. But for the interception of individual pulses, produced by a and the atmospheric atoms encountered on lines of propagation, it would be the same as if all the repellant matter considered were concentrated at the center of a. As a matter of fact, in consequence of this interception, the center of repulsion will be displaced toward the exterior atom b acted on. Beyond a certain minute distance the direct repulsion thus exerted upon b, will vary inversely as the square of the distance from a; and it will at the same time be less, at all distances, than the gravitating tendency originating in the manner above explained.

The excess of this tendency toward the atom (a) of ordinary matter above the repulsion exerted by the atom and its atmosphere, constitutes the effective force of gravitation due to the atom. It will vary, at all measurable distances, according to the law of inverse squares.

Before inquiring into the dependence of this force upon the quantities of matter in the active atom and in that acted upon, we will remark that nothing precludes us from supposing that *the atom of ordinary matter, so called, is actually a mass of condensed ether.* It will readily be seen that if a certain portion of the equally diffused ether lying around any point were to be condensed upon this point, the increased interception of the cosmical force within the space that it would occupy, would develop, as above explained, an inward acting force that might be in equilibrio with the augmented mutual repulsion of the atoms of the condensed ether. If this conception be adopted, the interception of the cosmical force, effected by an atom of ordinary matter, will take place at each of the ethereal atoms of which it is composed, and the entire effect will be proportional to the number of such atoms, or the entire mass of the compound atom. If then a second such atom of ordinary matter (B) be considered, at a distance from the first (A), the effective gravitating tendency of each of its constituent ethereal atoms toward A will be proportional to the mass of A. The entire gravitating tendency of B toward A, will then be proportional to the mass of A multiplied into the mass of B. Also, since the tendency of each ethereal atom of B toward any ethereal atom of A is inversely proportional to the square of the distance, the same law will hold for the entire gravitating tendency of B toward A. It is to be borne in mind that the effective force of gravitation here considered, is the excess of the gravitating tendency due to the partial interception of the general cosmical force by the atom A and its ethereo-electric atmosphere, over the repulsion directly exerted by the same.

The Newtonian principle of gravitation being thus made out for individual atoms of ordinary matter, it is also made out for cosmical masses. The Newtonian laws of the mutual gravitation of masses, in all their precision, are inevitable consequences of the principle of gravitation as now deduced from the one cosmical force of repulsion; if we admit that the portion of every impulse of this force that is intercepted by each atom is an excessively minute fraction of the whole intensity of the propagated impulse.

Molecular Forces.—The Molecular Forces, so called, consist of a force called the attraction of cohesion, and one or more forces of mutual repulsion. The force of heat is recognized as one force of repulsion, and has generally been regarded as the only repulsion in operation. But this notion must certainly be discarded by all physicists who maintain that the heat-repulsion is due to vibrations of the atoms of bodies; since such vibrations can only be maintained by the operation of existing antagonistic forces of attraction (or virtual attraction) and repulsion. And even if we admit, as I cannot do, the mechanical possibility of molecular motions of revolution, or rotation, so constituted as to originate in some way a force of heat-repulsion exerted in all directions outward from each atom, and to be always augmented in rapidity by waves of radiant heat from whatever direction received, it is wholly inconceivable that in the collision of bodies such motions of revolution or rotation of the impinging atoms, or molecules, should give rise to a mutual repulsion, whatever might be the relative direction of the motions. In fact, in whatever mode of molecular motion heat may be supposed to consist, if heat be the only force of repulsion, a certain amount of the living force of heat belonging to each of two impinging bodies would be expended in diminishing the velocity of the one body and augmenting that of the other, and it would be impossible that they should become heated by the impact. It is here assumed that the impact of two bodies must develop a force of mutual repulsion between the impinging molecules, which determines the equality of the action and reaction. This obvious fact seems now-a-days to be in a good degree ignored, and the exchange of momenta to be supposed to be brought about by some unimaginable process, in which the idea of force is wholly lost sight of.

We must then conclude that there is a primary force of molecular repulsion, in addition to that of heat. We might perhaps ascribe this force to the repulsion of the ethereal molecular atmospheres when brought into contact; but to what can we ascribe the heat-repulsion? It has come to be generally believed that it must consist in some mode of motion of the atoms, or molecules of bodies, as a whole; either of vibration, revolution, or rotation. But it might be almost demonstrated, did space permit, that this cannot be the true nature or origin of heat. I will only allude here to one or two arguments in support of this statement, which may be briefly given. It is well known that whenever any body is by collision with another body, or in any other way, permanently compressed, heat is given out. Now the fact that a force of pressure, or percussion, produces a permanent compression, increasing with its intensity, leads to the almost inevitable inference that in the act of compression the atoms, or molecules, experience some change of physical condition, by reason of which the molecular attraction is augmented, and the condensation maintained, and that this change must be proportionate to the degree of condensation, and so to the amount of heat evolved. Can such a change proportionate to the heat evolved, be connected by any admissible supposition with the augmented velocities of vibration, revolution, or rotation of ordinary atoms, in which the increase of heat is conceived to consist? In fact the entire phenomena of inelastic, as well of elastic reaction, point to the conclusion that they are attended with changes in the physical condition of the atoms, ordinarily so called, and that the evolution or absorption of heat that takes place is the direct result of these changes.

Again it is not conceivable that the phenomena of electricity can be ascribed to any imagined motion of ordinary atoms, or molecules, whether these are surrounded with ethereal atmospheres or not. We are accordingly constrained to look in some other direction for the origin of the molecular forces and agencies; and it appears to me that it is to be found in the general conception of an electric ether less subtile than the luminiferous, and gravitating like this toward the atoms of ordinary matter, so as to form envelopes to these atoms, permeated and underlaid by the condensed luminiferous ether. Each atom would thus be surrounded by an ethereo-electric atmosphere. The atoms of electric ether may be conceived to be masses of condensed luminiferous ether, but far more minute than those of ordinary matter. Adopting this conception of the existence of an electric ether, we are led, by legitimate inferences from the fundamental principles I have laid down in this paper, not only to the physical constitution of a primitive molecule, but also to the theory of molecular forces set forth in my memoir on Molecular Physics. The force of molecular attraction was conceived to consist in a contractile action exerted by the central atom upon its electric envelope, and originating waves propagated outward through the electric ether to contiguous atoms. This contractile action is now seen to consist in the gravitating tendency of the electric envelope toward the central atom; resulting from the partial interception of the cosmical force by this atom. This action also originates waves in the luminifereous ether posited between the central atom and its electric envelope, that are propagated outward by this ether, and constitute the primary force of heat-repulsion. All the diverse methods of developing heat are but different methods of compressing or forcing inward the atomic or molecular envelopes, and so originating ethereal heat-waves. These waves at the outset pulsate in the line of propagation; but, by passing around the ethereal atmospheres of molecules, become converted into waves attended with transverse vibrations. The other force of molecular repulsion originates in the direct repulsion subsisting between the diverse atoms of the electric envelope. This force originates waves that proceed outward through the electric ether from different depths in the envelope. These waves must increase in their intensity at the outset from the lowest depth upward, to a certain height in the envelope, by reason of the increase in the quantity of ether that is effectively repellant. On the other hand the attractive waves, that issue from various points of the envelope, must decrease outward in their intensity at their origin. It thus happens that the resultant waves, which may be taken to represent the entire actions of these two systems of waves, must be conceived to proceed from different depths; which depths may therefore be taken as the upper and lower limits of the effective envelope. This is equivalent to one of the principles adopted in the mathematical theory of the molecular forces developed in my former memoir; viz. that the attractive waves proceed from the lower limit of the electric atmosphere, or envelope, and the waves of electric repulsion from the upper limit. In the memoir referred to it was shown that the entire action of one atom, or rather primitive molecule, on another, amounts to a repulsion at the more minute distances, and an attraction at greater distances up to a certain limit, beyond which it becomes a repulsion to an indefinitely great distance. The first mentioned, or inner repulsion, and the attraction, are the forces which determine and maintain the solid and liquid condition of matter, and the outer repulsion constitutes the expansive force of vapors and gases. The extraneous heat that a body may receive is a distinct force of repulsion, modifying the natural curve of molecular action.

Origin of Chemical Attraction, and of Electric and Magnetic Forces.—The electric envelopes of atoms, besides being the source of the molecular forces, including the primary heat-repulsion, invests the molecules of each substance with the property of chemical attraction for the molecules of other substances to which they bear a certain physical relation. This consists in the disturbance of the equal distribution of the ether in the envelopes of two contiguous heterogeneous molecules, under their natural molecular action, by reason of which the molecules become oppositely polarized on their adjacent surfaces—the one having an excess of the electric fluid and the other a deficiency. The attraction thus originating may prevail over the natural molecular repulsion that comes into play when the two liquids come into contact, and bring the molecules within the range of their natural attraction.

The state of molecular electric polarization, superinduced under certain varied circumstances, originates the galvanic current, and determines the phenomena of electro-static, electro-dynamic, and magneto-electric induction. The attraction and repulsion of electric, and of magnetic currents, may be ascribed to the origination and maintenance of currents in the adjacent body of luminiferous ether, running in the same direction as the electric or magnetic currents. These currents determine inequalities of elastic force in this moving mass of ether, from which result *transverse currents.* These transverse currents take effect upon the line of the electric or magnetic current because they are partially intercepted by it. The induction of one electric or magnetic current by another, is effected by the intervention of currents directly induced in the adjacent body of luminiferous ether.

The key to the explanation of the excitation of electricity by friction lies in the fact made out in my former paper, that the electric ether is condensed between the component molecules of each compound molecule of a substance; and that every expansion of the compound molecule sets free a certain portion of this condensed ether, and every condensation withdraws a certain portion from adjacent molecules that are undisturbed. If two dissimilar surfaces are rubbed, the one over the other, the consequent disturbance of the compound molecules of the two surfaces, will be either unlike or unequal in amount; and a certain quantity of electricity will in consequence pass from the one surface to the other. As soon as the friction ceases the disturbed molecules will recover their original form and size, and the positive state of the one surface and the negative state of the other will manifest themselves. For example, if the molecules of the one surface are compressed by the rubbing, and those of the other expanded, electricity will flow from the latter to the former while the condensation and expansion are going on, but as soon as two rubbing molecules are freed from each other's influence they recover their former dimensions, and the excess of the electric fluid in one of the molecules and deficiency in the other become positive and negative electric states. Non-conduction consists in a comparative deficiency of electric ether in the interval between contiguous compound molecules, by reason of which a transmission of electric movement does not readily occur from one to the other. I have shown in my paper on Molecular Physics that in such cases an electric polarization of the molecules is induced, which develops a resistance to the electro-motive force.

The excitation of electricity by heat is conceived to be principally due to the expansive action of heat on the electric envelopes of primitive molecules, and on the compound molecules, which either sets free a certain portion of electric ether, or establishes a chain of electro-polarized molecules.*

General Considerations.—The Theory of Cosmical and Molecular Physics, of which I have now given a brief outline, rests essentially upon the following principles.

(1.) *The doctrine of inertia* applicable to all matter.

(2.) *The existence of a single primary force of repulsion* exerted by every atom upon every other atom. This force is universally admitted to be in operation between the atoms of the luminiferous ether, and between the atoms of ordinary matter and this ether at the most minute distances.

(3.) *The existence of but one primary form of elementary matter*, viz: the universal or luminiferous ether;—the atoms, so called, of ordinary matter and of the electric ether being but different masses of condensed luminiferous ether. The theory of the

* For the more complete exposition of my theoretical views I must refer the reader to the memoir on Molecular Physics.

origin of universal gravitation that has been propounded might be reconciled with the ordinary notion of matter, viz: that its atoms are essentially different from those of the ether, if we could admit that the resistance of an ordinary atom to a force giving it motion was proportional to its surface instead of its mass.

(4). *The doctrine of the interception of force*, as already set forth.

(5). *The primary force of repulsion is made up of impulses recurring with an immeasurable rapidity.* This is no new hypothesis. In all treatises on Mechanics, gravity, and all incessant forces, are conceived to consist of an indefinitely great number of impulses taking effect in a finite interval of time.

If we conceive the propagation of the primary force of repulsion to be by the intervention of a medium, this medium must be an ether more subtile, and endued with a more intense elastic force than the luminiferous. This elastic force must consist in a mutual repulsion between the atoms. Thus, upon the idea of a material propagation of force, we must ultimately rest upon the conception of a force exerted between two atoms separated by a finite though excessively minute interval of space. There is no tenable position between this and that of a plenum.

Let us here devoutly acknowledge that in thus following the chain of cause and effect into the precincts of that most deeply hidden of all mysteries, the origin of force, we have come into the presence of the Infinite Spirit who puts forth unceasingly, from every point in the realms of space, His creative and sustaining power upon the subtile matter that fills all space, and is the essential substance of all worlds.

In addition to the principles just stated, we recognize the existence of matter in the three states of *the luminiferous ether*, *the electric ether*, and *ordinary matter*.

It hardly need be stated that among the consequences of these fundamental principles is included the doctrine of the *Conservation of Energy*, actual and potential. It is obvious that at any point in the boundless sea of ether the same amount of cosmical force would be received from every direction, but for the existence of the innumerable worlds dispersed through it. It is also true that in the mutual gravitation of each pair of cosmical bodies, resulting from the interception of the cosmical force, the amount of this force expended in giving motion to the one body will be expended in precisely opposite directions in giving motion to the other body; so that on the whole the cosmical force in operation in any one direction is equal in amount to that in operation in the opposite direction. Also the amount of energy taken up in the half revolution during which the one revolving body is approaching the other, is given out during the remaining half revolution in which it is receding and returning to the original position.*

The kindred principle of the mutual convertibility, or "Correlation of Physical Forces," including among these the living force of moving bodies and of the atoms of all bodies, is obviously an essential feature of our general theory. For heat is regarded as being in its origin a wave of translation in the luminiferous ether, and an electric current is a similar wave in the electric ether, and the conversion of one of these into the other, or into the motions of ordinary matter, is merely the transfer of the living force of moving matter from one of the states or forms of matter to another. The heat developed in chemical attraction, is the amount of living force in the waves of luminiferous ether originated by the compression of the electric envelopes of the uniting molecules; and the force of attraction is expended in the act of originating these waves, and must be equal to the living force propagated in them. In the chemical union of two atoms, or primitive molecules, the "clash of atoms" that takes place cannot be succeeded by a perfectly elastic mutual repulsion, since such a repulsion would completely separate them, and restore them to their condition before the attraction came into operation. Now the loss of elasticity, which renders the union possible, consists in the outward movements imparted to a certain portion of the luminiferous ether lying between the uniting atoms and their electric envelopes, by the forcible compression of the envelopes, resulting from the clash of the atoms; and these movements constitute also the living force of heat developed.

The heat produced by extraneous pressure, or by impact, is the work done by the force of pressure in compressing the molecular envelopes, in opposition to the resistance of the

* The ever-recurring pulses of the primary cosmical force, emanating from all the atoms of the one, primary matter, are directly consumed in communicating opposite movements, or virtual movements, to every atom in the universe. It is, as I conceive, because in the existing condition of things the distribution of matter is unequal in different directions around a point, and therefore the partial interception of the impulses of the cosmical force along the different lines of direction unequal, that an effective gravitating force exists. The entire amount of the cosmical force consumed in any interval of time is the amount intercepted by all the atoms of matter, and is independent of the motions that result from the inequalities just noticed. Gravitation, and molecular and chemical attractions which originate in the gravitation of electric ether toward atoms of ordinary matter, are then derivative forces, incidental to the direct actions exerted by the cosmical force upon the atoms. The heat which escapes from the sun, or any cosmical body, into space, represents only a certain amount of the general gravitating force previously expended in imparting movements, in waves of translation, to the luminiferous ether. The electric current, wherever it exists, represents a certain amount of the same force, expended in imparting similar movements to a certain quantity of electric ether at the source of the current. In other words, the escaping heat and the electric current each represents a certain amount of work done, either by the gravitating tendency of electric ether toward ordinary atoms, or by that of ordinary atoms toward each other.

luminiferous ether posited below them, transformed into the accumulated work of the ethereal waves set in motion by this compression. The deficiency of elasticity, essential to the development of the heat, consists in this escape of the ether in waves of translation, and the attendant loss of living force; and the permanent compression of the impinging bodies results from the change in the molecular forces, consequent upon the permanent compression, or forcing inward of the molecular envelopes.

The principle of the "Correlation of Physical Forces," involves (as above implied) with it that of the "Conservation of Force," maintained by modern physicists, viz: that all transformations of one physical force into another take place without any loss, and therefore the store of living force in existence in nature is invariable.

The idea seems now to be commonly entertained that the entire force in operation in the universe is the result of certain motions imparted to all matter at the creation, and so being ever equivalent to the living force embodied in these primordial motions, must be invariable. But a gravitating force is always operating to deflect each revolving body from the tangent to its orbit, and a certain amount is continually being expended in this act, so that if the force of gravitation were due to preëstablished motions, it would be continually wasting away, and the entire amount of force in the universe would be perpetually diminishing. The sum total of the individual forces taking effect throughout all nature may indeed be constant, but if so it is because the flux of the primary force of repulsion is uniform, and is consumed primarily by interception from all atoms, incidentally in maintaining the motions of revolution of all the cosmical bodies (in the universe), and all the molecular forces perpetually neutralizing each other within these bodies.

From our present point of view we may also discern that the physical forces, ordinarily so called, have an entirely different origin from that above mentioned. We may perceive that they are all either the direct or indirect result of the operation of the general force of gravitation, which is itself a consequence of the operation of the cosmical force of repulsion. Gravitation is the direct agent in two general classes of phenomena, viz: the revolution of one cosmical body around another, and the act of condensation of every such body upon its center of gravity. In the former the motion is curvilinear, and all the living force imparted by gravity to either body, while the two are approaching each other, is taken out, by the operation of the same force in opposite directions, while they are receding from each other; and this alternation has continued from the first without loss of living force, from one revolution to another. But, in the act of formation of the existing cosmical masses by condensation, the motions of their elementary parts have been directed toward the center of gravity of the mass, and the mutual destruction of such opposing motions has developed an equivalent amount of living force in the form of heat, that is in the form originally of waves of translation proceeding from the ethereal atmospheres of the condensed molecules. By the continued operation of the gravitating force, in the sun and earth, and probably in innumerable other worlds, the transformation of the work of condensation effected by this force into an equivalent store of heat-work is constantly going on. The heat of chemical combination, as well as that of liquefaction and solidification, are attributable to the gravitation of the electric ether toward the atoms of ordinary matter. All the heat and attendant light evolved since the creation form a store of accumulated work equivalent to the work done by the force of gravitation in effecting all the condensations that have hitherto taken place. This heat and light force has been in its natural operations opposed to the force of gravitation, and so essentially a separating and decomposing force. It has been the great physical agent in all the processes of vegetable and animal life. It has ever been passing through cycles of transformation into other physical forces, but in all its transformations the entire amount of energy, actual and potential, has remained invariably the same. Chemical combination, the electric current, liquefaction, and solidification, are instances of motion directly due to the general gravitating force operating on the electric ether. All motions of translation or rotation of bodies at the earth's surface are traceable directly to the same force, or to that of heat repulsion and therefore indirectly to that of gravitation. We may accordingly lay down the postulate, that the entire circle of what are termed physical forces have originated in the living force of the motions of condensation that have resulted from the natural operation of the general gravitating force, initiated at the dawn of creation and continued through all time. The very process of formation, by gradual condensation, of the worlds that people immensity, has developed the natural forces which have presided and continue to preside over all the processes of change that diversify and beautify their surfaces, and fit them to be the abodes of living beings. These diverse natural agents are but the offspring of the one overshadowing force, which, in the progress of countless ages has formed all worlds out of the primordial material fashioned by the Hand of the Creator. We may indeed, as we have seen, rise to a still greater height of conception, and refer this universal force to a primal force of cosmical repulsion, associated by the Infinite Spirit, the Source of all Power, with every atom of the one primeval matter that fills immensity, and is the elementary substance of all worlds.

Art. IV.—*The Photo-mapper;* by Henry M. Parkhurst.

It is a remarkable fact that while vision is by far the most accurate of our senses, aiding us almost exclusively in obtaining accurate measures, we have as yet discovered no method of measuring the intensity of light. The method of measuring the brightness of a star by extinction, for example, is in fact merely a method of assisting the eye in estimation. If we were to measure the diameter of a sphere by removing it to such a distance that it should cease to be visible and multiplying that distance by a certain constant; or by subdividing it until we could divide it no longer, or until the atoms should have no appreciable weight, and multiplying by a constant; it would be analogous to determining the brightness of a star by ascertaining what proportion of its light is too small to affect the retina.

The true mode of measurement is by substraction of certain known quantities. To illustrate the advantage of this, were the difference of brightness of Arcturus and Capella but $.01^{m}$, that difference would be visible to the naked eye; and were it but $.0001^{m}$, it would be easily visible with telescopic aid. Could we construct a glass which would transmit, not a certain proportion of the whole light of a star, but all its light exceeding a certain absolute quantity, it would afford us a perfect photometer. Or could we construct a glass which should transmit polarized light, but which would not transmit common light, that would accomplish the same result. But in the mean time we may be allowed to designate estimations assisted by mechanical means as measures of the magnitude of a star.

My first experiments in determining by mechanical means the magnitude of stars observed in zones, and recording that magnitude at the time of observation on star-maps taken by the instrument described in the Journal for September, were made in 1865. I then constructed a hexagonal diaphragm so arranged that a series of six plates over the object glass, moved simultaneously by a lever extending the length of the telescope, gradually diminished the aperture until the star ceased to be visible. I connected this lever with the system of levers operated by the star-key, and recorded upon the map, in the same right-ascension with each star, a point whose position indicated the aperture at the moment of extinction, and therefore gave by a prepared scale the magnitude of the star.

My next step was to avoid the long and cumbrous lever by adopting the principle of the apparatus invented by me in 1860, and which I term a Bar Photometer, reducing the cone of light from a star at a point intermediate between the object-glass and its focus, instead of directly reducing the aperture at the object-glass.

At a convenient point, say one-eighth of the distance from the focus to the object-glass, I place in the meridian a straight bar one-eighth of the diameter of the object-glass in width. Clamping the telescope a little to the west of a star, the cone of light is gradually intercepted by the bar, and gradually re-appears. The time during which the star is extinguished, or during which it remains of less brightness than a standard artificial star in the field, indicates the brightness of the star by the proportion of the light cut off by the bar at the moments of occultation and reappearance.

A modification of this plan, is to make the bar wider, so that it shall become a diaphragm, with a central aperture of the width of the cone of rays, observing the duration of apparition instead of the duration of occultation of the star.

By either of these methods the scale may be made one of equal parts by a device similar to that which will presently be explained. With or without such a device, this method is well adapted for observations of small variable stars, requiring no apparatus but the bar, whose distance from the focus shall be so determined that photometric accuracy shall not be sacrificed, while there shall be no unnecessary consumption of time. Indeed a plain Bar Photometer can at any time be extemporized in a few minutes. Its adjustment in width or distance is not essential, because its position and width can be determined and the proper connections made without difficulty after the observations.

A further modification of this plan, is to revolve the diaphragm 90°, and make it movable in declination, occultating the star on both sides of the center of the field, the magnitude being indicated by the extent of the motion, which may be conveniently and accurately measured, with a dim light, by a pair of dividers.

By a still further modification, the motion of the diaphragm may be produced, by means of intermediate levers, by the star-key of my star-mapper; and this constitutes the Photo-mapper, which I will now more particularly describe.

The diaphragm is moved parallel to itself in an arc corresponding to that described by the star-point and star-key, being supported and guided by two parallel bars whose bearings are screwed to the east side of the telescope tube. The diaphragm being seven-eighths of the distance from the object-glass to its focus, the length of the supporting bars is seven-eighths of the radius of the star-point. As I use a camera-prism, which slightly shortens the focus, I have, in my instrument, made the proper corrections, but need not here refer to details of that description.

On the same center with the star-point, and star-point-bar, shown in fig. 1 of my article on the Star-mapper, is another bar placed parallel to the axis of the telescope, pointing toward the object-glass. The further end of this magnitude-bar is connected at right angles by a connecting-rod with universal joints, with the upright arm of a lever, the lower arm of which is the lower supporting-bar. The length of this upright arm and of the magnitude-bar must be equal. In photo-mapping I place the prism always in the meridian, to avoid the complicated adjustments which would be necessary if its position were to be varied.

As the diaphragm will move seven-eighths as fast as the star-point, it is evident that if it is so adjusted that it will not intercept any of the light of a star in the center of the field when the star-point is brought to the declination of that star, then in mapping a northern or southern star in the field its light will be unobstructed. But moving the star-key to the north or south of a star will intercept part of its rays. The light of the star being thus equalized with that of a standard artificial star, or extinguished, as the case may be, a magnitude mark is impressed on the paper. The star is then mapped in its proper position, and the distance upon the map, of the magnitude mark from the corresponding star, will be the measure of the magnitude of that star.

A perpendicular plate, with a circular hole through which the connecting-rod passes, furnishes a convenient point from which to measure with dividers when the instrument is used without the mapper.

Thus far I have spoken of the "cone" of rays, as if the aperture were circular. If it were so, the scale of magnitudes would not be one of equal parts. It may be made one of equal parts by placing over the object-glass an outer diaphragm with an aperture of suitable form, and making the aperture of the inner diaphragm of corresponding form.

Let $x=2{\cdot}5[y]$ be the equation of a logarithmic curve. Then, the area between any two ordinates of that curve will be $2{\cdot}5\mathrm{M}\Delta y$; M being Modulus. Constructing for the object-glass of 6 inches aperture a diaphragm bounded by four such curves, with values of x ranging from $-1{\cdot}5$ inches to $+1{\cdot}5$ inches, laying off x vertically, above and below the center, and y to the right and left, and a similar inner diaphragm of one-eighth the lineal dimensions, neglecting for the present the portion of the curve which will pass outside of the circle, it will be seen that the motion of each one-fourth of an inch of the inner diaphragm will leave an area corresponding to stars exactly one magnitude smaller. The motion of the star-point will be one-seventh greater, and of the star-key still greater, according to the scale of the map.

But while the object-glass is limited, the inner aperture may extend beyond the corresponding circle of one-eighth the diameter. If therefore an area equal to twice the omitted portion of the curves above and below is added to the inner diaphragm, it will be almost immediately available, and the omission from the outer aperture will cause an error of less than $\cdot 1^{m}$, and that only at the commencement of the scale. The proper form of this added portion is the inversion of the last $1^{\cdot m}2$ of the curve within the circle, the final value of y being exactly three times its value at the margin of the disk.

With the diaphragms thus constructed, the scale runs through $3^{\cdot m}0$ as a scale of equal parts. Beyond that point the star may still be extinguished, if not too near the center of the field; but the scale will be condensed.

The stars occurring in any zone may be divided into three classes: those above the $6^{\cdot m}5$ being approximately measured by the condensed scale, and being so few in number that they may be conveniently, as well as more accurately, measured by a different method, to be explained below; those between the $6^{\cdot m}5$ and the $9^{\cdot m}5$, which may be equalized in brightness with an artificial star in the field previously brought to an equality with a $9^{\cdot m}5$ star; and those fainter than the $9^{\cdot m}5$, which may be extinguished. The outer diaphragm will so diminish the aperture that $12^{\cdot m}5$ stars will be the smallest which can be seen.

The Disk Photometer.—For the brighter stars I employ an entirely different apparatus, based upon a more accurate method. I expand the stars into disks by drawing out the eye-piece beyond the focus, until a portion of the disk shining through an aperture in the field of view shall either be exactly equal in brightness with an adjacent luminous disk, or be imperceptible. The extinction of a disk by expansion is only practicable with a small aperture or with telescopic stars, and is not much, if any, more accurate than extinction by reducing the aperture. But comparison of disks, especially for the stars visible to the naked eye, is the most accurate means of measurement known to me, the error of the comparison being in my experience less than the inequalities of the artificial disk, and the latter much less than those of the sky.

The star and the disk can be compared, if desired, by the aid of polarization, by the use of a double-refracting prism to combine the two disks into one, and a selenite plate and another double-refracting prism to form new colored disks; but instead of producing the final adjustment by further polarization, the bundle of plates may be dispensed with, and the disks rendered colorless by the motion of the eye-piece.

For convenience I have made a slide with six equal openings, to shade the disk with neutral shades, and a slide to shade the star. I ascertained that one shade was equivalent to $1^{\cdot m}03$, and that, although I admit the rule would not be accurate with colored shades, five neutral shades were equivalent to 5·^{m}15. It is therefore convenient to compare directly stars differing as much as α and λ Ursæ Minoris. In order to neutralize the yellow color of the artificial disk, and to make it appear indistinguishable from the visible portion of the disk of a star, I have found it necessary to use a blue shade. I have extended the telescope by various tubes, sometimes nearly two feet; but with the use of the slides I find that a tube five inches long to hold the eye-piece, usually gives sufficient extension to the telescope and sufficient range of brightness. The amount of the extension I measure with dividers, using a prepared scale which gives directly, in magnitudes, the difference in brightness between the observed star and a standard depending on the brightness of the disk.

The disk photometer is especially useful for observing the brighter variable stars. It is inapplicable for determining the brightness of stars so close together that the space between them is not sufficient for a disk; but in this case it may be used to determine the aggregate brightness of the two stars. It may be used for measuring the brightness of planets, small nebulæ and comets, probably of the moon, and possibly of the sun.

The same apparatus may be used to determine the comparative brightness of different portions of the sky, but requires a different process.

The error of the determination of the magnitude of a star by the method of equalizing disks, may be divided into four parts:

I. The error of the assumed magnitude of comparison stars. In my series of observations, instituted to determine the relative amount of the several errors, this error hardly exceeds ^{m}·01.

II. The error of observation, or inaccuracy of judgment as to the exact point where the disks are equalized. Not only according to the statements of Arago, Silliman, and Crookes, reduced by myself, but according to my own results, the error of observation—I refer to the *mean* error—does not exceed ^{m}·02, in a series of stellar observations averaging forty to the hour. For fainter stars than I observed in my series, the error of observation is greater. There are three limitations:

1. One disk cannot be distinguished in brightness from another, unless one-sixtieth brighter or fainter, according to Arago.

2. One disk cannot be distinguished as brighter than another, if the subtraction of the light of the fainter disk from the other would leave a disk too faint to be visible by itself. The same principle is applicable to points of light. Unless, therefore, the disk is at least sixty times as bright as is necessary for visibility, the error of observation will be greater.

3. If the disk is small, the accuracy of comparison is impaired. Hence points of light cannot be as accurately compared as disks. I have used a disk of an apparent magnitude of at least 1°, and have not investigated the amount of error with a smaller disk.

III. The error from the variation of the artificial disk during observation. I have made many and careful experiments to render this error as small as possible, and to avoid ascribing to the irregularity of the sky discrepancies which might be owing to variations of the artificial disk. The brightness of the artificial disk may vary from four causes:

1. The illuminating quality of the gas may vary. Hence observations on different evenings cannot be compared directly. But the change of the gas will be so slow, excepting probably from the heating of the apparatus when it is first lighted, as not to appreciably affect the results.

2. From variation of the pressure the flame may be made larger and brighter. I first partially corrected this by forming upon the screen an image of a circle of the flame ·05 in. in diameter. I afterwards made a gas regulator, admitting the gas into an inverted receiver suspended at one end of a lever, the other end of which gradually shut off the gas as the receiver rose; so that whatever the pressure of gas in the mains there should be no variation in the flame.

3. The flame varies in different parts. Hence, if on turning the telescope upon a new star the lantern is not accurately adjusted to a horizontal position, a brighter or fainter portion of the flame will come opposite the aperture. The flame as a whole having been made uniform by the regulator, I have introduced a smoothly ground glass at the aperture nearest the flame, and reduced the flame and moved it further back, so as to use the whole flame.

4. The light from the star is a sharp cone, wholly entering the eye even if withdrawn several inches from the eye-piece. The light from the illuminated screen is a hemisphere. Unless therefore the eye-piece renders the rays parallel, which it will not if the observer is either near-sighted or far-sighted, a difference in the distance of the eye will greatly affect the results. I have therefore turned the plane glass in the eye-piece so as to throw the light directly into the eye, reducing the aperture of the lenses so that the cone of rays from the artificial disk nearly corresponds with that from the star. It is necessary that the eye should be held so that both cones shall completely enter it at once, which can be easily accomplished but requires care.

The error from the variation of the artificial disc, without the gas regulator, I ascertained not to exceed ^{m}·04. How much this has been reduced by introducing the regulator and ground glass screen, I have no means of estimating.

IV. After allowing for the previous errors, amounting in the aggregate to less than $^{m}\cdot05$, the remaining discrepancies of observation of invariable stars must arise from variations of the apparent brightness of the stars from atmospheric obscuration. I divide this into two parts:

1. The general and permanent obscuration depending on the altitude of the star. I have ascertained that this follows the law of refraction; but the coefficient varies in amount on different evenings, sometimes equalling $^{m}\cdot50$ for an altitude of 20°, and at other times not exceeding one-third that amount. I apply the correction for obscuration to each star, in reducing the observations, so as to eliminate this; and I therefore regard it as no part of the error of observation. The correction may be easily applied without directly determining the altitudes, by a prepared scale.

2. The temporary and local obscuration, from various atmospheric causes. By more than 400 observations of 18 stars of the 2nd to the 4th magnitude, α Persei and γ Arietis being the extremes, I found that the average mean error of an observation, from all causes, amounted to $^{m}\cdot11$; so that the mean error from the temporary and local obscuration alone is on the average $^{m}\cdot10$. There is a great difference between different days; the average mean error of all the stars being sometimes as low as $^{m}\cdot07$ for a whole evening, and at other times for an evening apparently equally clear, as high as $^{m}\cdot20$. The difference between the stars is no less conspicuous. The stars ε and γ Persei are near each other, and nearly of the same brightness. Yet the mean error of an observation of γ Persei, assuming it to be an invariable star, is nearly three times as great as of ε Persei.

It is evident therefore that if the results I have reached are even approximately correct, the errors of observation and of the instrument, if ordinary care is used, are of no material consequence; and accurate results can only be obtained by multiplying observations on different evenings, so as to eliminate as far as possible the errors arising from the variations of the sky.

Art. V.—*On the Crater of Haleakala, Island of Maui, Hawaiian Group;* by Prof. W. D. Alexander. (From a letter to one of the Editors.)

I have just been spending a summer vacation on Maui, and in the course of it made a careful survey of the great crater of Haleakala. During the vacation I went three times to the summit. The first time I rode up from Makawao before sunrise, and spent about seven hours in collecting mineral specimens and plants, and forming a plan for the survey of the crater. The flora of this region has been described before. I will only say that the principal plants that survive on the bleak summit are the *Argyroxiphium*, *Raillardia montana*, *Vittadinia*, and some stunted ferns, viz: *Pteris aquilina* and *Trichomanes.* In the belt between one and four miles from the summit, in addition to the above, are found the beautiful *Geranium cuneatum*, *Sophora chrysophylla*, Sandalwood, *Coprosma*, and a few ohelos (*Vaccinium reticulatum*). Water boiled at 193° Fahrenheit when the atmosphere was at 46° Fahrenheit. At sunrise we enjoyed the grand sight of the vast triangular shadow of the mountain projected on the clouds in the western sky.

On the morning of August 4th, I ascended the mountain again from Makawao, with five natives, and furnished with a superior theodolite, a dozen large bamboos for signal poles, a good tent, and provisions for a week. We spent seven days on the mountain, and enjoyed almost uninterrupted fine weather.

We commenced operations by setting signals on the prominent points along the western side of the crater. The western cliffs are very steep, though it is possible to descend in many places, and are from 2,000 to 2,500 feet high. We pitched our tent on the lee side of a hill near the southwest corner, called by the natives "Pakaoao" or the "fortress of Kaoao." This hill is composed of a light gray solid clinkstone, which splits into laminæ like slate.

It has been much shattered, probably by the terrible convulsions that attended the opening of the Koolau gap, and for a quarter of a mile toward the northwest the ground is strewed with fragments of rock that have been hurled in that direction. These rocks form a striking contrast with the darker and more basaltic rock to the northward. The same formation crops out on the east side of the Koolau gap, at the southern foot of Hanakauhi in the oasis surrounded by recent lava, at which place it projects from the hill side in the form of huge perpendicular slabs or lamellar masses, not more than ten feet thick, and from thirty to fifty feet high, standing out of the grassy slope like immense grave stones. The patches of gravel on the summit contain numerous crystals of augite. The hill called the fortress of "Kaoao" is partially terraced on the lee side, and is covered with hundreds of little inclosures built of stone, three or four feet high, and paved with thin flat pieces of clinkstone. I noticed that a few had been covered over with a kind of slate roof. Here, according to tradition, encamped the army of Kaao, a chieftain who had been driven out of Kaupo by his rival, some time in the early part of the last century. We found a couple of ancient sling stones in the camp. Many silver-swords (*Argyroxiphium*) and other plants have grown up, flourished and died in the *pas* where his army once encamped. I was told that they drew their supplies from *Kula*, the district on the west side. Other natives relate that the sandalwood cutters used to encamp there forty or fifty years ago, when collecting sandal wood for their chiefs. The chief, Kaao, was finally defeated and killed in a battle fought on the west side of the mountain.

Our supply of water was brought from a water-hole two or three miles west of *Kalahaku*, which is only known by a few of the natives. We spent three nights on the spot.

About a quarter of a mile farther south is a red scoria hill, which is the highest point of the mountain, 2,750 feet above the bottom of the crater. It is the first of a long line of scoria hills which extends to the sea on the southwest, passing through Capt. Makee's plantation, and is called *Kolekole.*

The true meridian was obtained by careful observations on the pole star when on the meridian taken at this point and also at the east end of the base line in the crater. The fact had been noticed before that there is a considerable local attraction in the walls of this crater. I found that certain rocks of a compact bluish lava on the highest point were decidedly magnetic. Pieces of this rock have distinct polarity. There was evidently a large daily variation of the needle; between sunrise and noon the needle moved at least half a degree westward, and returned to its former position at night. On the morning of the 5th there was a heavy frost around our camp, the thermometer at sunrise standing at 38° Fahr. The average temperature at noon was 72° in the shade; the temperature in the crater averaged about 4° higher. After selecting stations and setting up signal flags along the western and southern sides of the crater, we descended into it at the southwest corner, along an immense sloping bank of reddish sand and scoria. We then marked out a base line more than a mile and a half long over a level plain at the foot of the southern wall of the crater.

This plain was sprinkled with myriads of silver-swords (*Argyroxiphium*), many of which were in full bloom, presenting a magnificent sight. These plants are most abundant over the volcanic sand in the central part of the crater. Both in descending into the crater and on our return, we followed a beaten path, which leads through the southeast gap to Kaupo. Our party were somewhat affected by the rarity of the air; we all experienced shortness of breadth, and some complained of headache, but after spending a week in this region, we became accustomed to the air, and our "wind" improved wonderfully.

The natives have many local names for different parts of the crater. The term *Haleakala* properly belongs to the southeastern part of the mountain, extending two miles west from the

Kaupo gap to the low place in the wall of the crater, called the "Puali" or pass of "*Koanui o Kane.*"

On the eastern side is a famous rock called *Pohaku Palaha*, which is the "hub" of East Maui, from which all the boundaries between lands are believed to radiate.

The next day, the 6th, we moved our tent and baggage four or five miles into the crater, and encamped near a cave called "*Ke ana ma ka uahi*," i, e, the smoky cave, half a mile from a trickling stream on the southern wall called "the water of Palaoa." This place we made our head-quarters for three days, during which we enjoyed almost cloudless weather, and our survey made rapid progress.

There is much more vegetation in the eastern end of the crater than in the western. On the sloping walls of this part of the crater, and on the three easternmost cones we noticed a good many mountain plants, such as *Dodonæa*, *Sophora*, *Raillardia* and *Geranium*, and on the summit of the southeastern walls of the crater, we observed clumps of large trees. This vegetation gave this region a very different aspect from the stern desolation of the western end. Near the commencement of the Kaupo gap, close to the road, there is a famous water-hole called "*Ka wai pani.*" Here, as I am told, there is a subterranean stream of pure cold water, two or three feet below the surface, which is reached through a small hole in the rock, which was formerly kept closed by a large stone, whence its name, "the closed water."

The scenery around us was entirely unique, and as grand in its way as that of the Yosemite valley. The vast plain surrounded by black precipices nearly twenty miles in circumference, and from 1,000 to 2,500 feet in height, with the two wide breaks through which we had glimpses of the distant ocean, the sixteen crater cones, of different colors, gray, red and black, the profound solitude and silence broken only by the flocks of wild goats, formed a scene to which it would not be easy to find a parallel elsewhere in the world. I ascended several of these cones in the course of my triangulation, and found the highest to be over 750 feet in height above its base. Another measured 390 feet, and several are over 200 feet in height. They are composed of light scoria and cinders, generally of a deep reddish color, but two are of a peculiar gray tint, and others nearly black. I found no traces of sulphur and very little pumice. The cones all have their ancient names, which are known only by the mountaineers and old natives. For instance, the highest cone is called "*Ka lua o ka Oo*," the crater of the Oo, and was the former residence of Kamohoalii, Pele's younger brother, "the king of vapor," of whom many legends are told. Another was called "*Ka iwi o Pele,*" Pele's bone, and close by it on the north side is the *Pa puaa o Pele*, or "Pele's pig-pen." This is a singular natural formation of lava, about two rods square and ten feet high, with an opening on the northwest side. Some of my men believed that if any one should *kaha*, i. e., scratch the sand in this place or otherwise desecrate the sacred precinct, the evil spirits of the mountain would bring on fog and rain. A similar superstition attaches to the *Argyroxiphium*, or silver-sword plant. The natives also report a bottomless hole on the northwest part of the crater, which I did not visit, but which has been seen by my father and others.

After returning to our first camp on the summit, we spent another day in visiting the stations around the south and west sides, and measuring the remaining angles, and returned to Makawao late in the evening of the 11th. After having worked up my notes and drawn a map of the crater, I visited the summit once more on the 25th, to compare my map with the original on the spot, and to make the details more exact.

According to the results of my survey, the crater is of an oval shape, its longest diameter being nearly east and west, unlike most of the Hawaiian volcanoes, the major axes of which generally range north and south. The greatest length of the crater was found to be about seven and a half miles from east to west, the width being from two and a quarter to three miles. The area is about sixteen square miles.

The highest point was determined by the United States Exploring Expedition to be 10,217 feet above the level of the sea, and 2,783 feet above the bottom of the crater. I made its height by triangulation 2,750 feet above the east end of my base line in the crater. The boiling water experiment gave an altitude of 10,165 by Regnault's rule, which is certainly a close approximation.

The northern or Koolau break is about three miles wide, and over 2,000 feet deep, where it first leaves the crater. The western brink of it bears about N. 64° E. The bottom of it is floored with streams of lava of different ages, and is extremely rugged.

The southeast or Kaupo break is about a mile and a quarter wide, and its direction for the first three or four miles is about S. 58° E. The lava flow then turns to the southward, and continues in the direction S. 34° E. to the sea, spreading out in the form of a delta, and filling up the lower part of several large ravines.

The appearance of the lava fields and cones in the eastern end, and the vegetation on them seem to indicate that they are far more ancient than those in the western end. The latest action in the crater seems to have been the formation of the cinder cones in the southwestern part.

To conclude, the survey has impressed me with the conviction that this is a real terminal crater, and not merely "a deep gorge open at the north and east," or a *caldera*. I have indeed heard the theory proposed that the mountain is but the wreck of a complete dome with a small terminal crater, the whole top of which has fallen in and been carried away, as is supposed to have been the case with some of the volcanoes of Java, and the Caldera of Palma. Such questions I leave for geologists to settle, and if I can furnish them any new data on the subject, I shall be quite content.

Oahu College, Oct. 12, 1869.

ART. VI.—*On a new method of separating Tin from Arsenic, Antimony, and Molybdenum;* by FRANK WIGGLESWORTH CLARKE, S.B.

SOME time since, happening to notice that the remarkable highly crystalline precipitate formed by oxalic acid in a solution of stannous chlorid was not blackened or otherwise affected by sulphuretted hydrogen, I was led to a series of experiments concerning the action of the above named acid upon certain metallic sulphids, and obtained the following results.

Both sulphids of tin, if moist, and freshly precipitated, are readily decomposed by moderately long boiling with an excess of oxalic acid, H_2S being given off. The monosulphid is converted into the insoluble, crystalline stannous oxalate, while the yellow disulphid is completely dissolved. The commercial "mosaic gold," however, seems to be unacted upon by the reagent. In presence of an excess of oxalic acid, tin cannot be precipitated by H_2S.

The sulphids of arsenic, even upon very long boiling with the acid, are almost unattacked. Very minute traces of the metal sometimes go into solution, but may be reprecipitated by a bubble or two of H_2S. Accordingly, the presence even of an enormous excess of oxalic acid does not hinder the precipitation of arsenic as sulphid.

The sulphid of antimony behaves in a somewhat different manner. Although upon long boiling with oxalic acid considable quantities of the metal are taken into solution, yet every trace of it may be reprecipitated by H_2S.

Molybdic trisulphid appears to be wholly unattacked by oxalic acid, even upon very long boiling.

With the sulphids of tungsten I have obtained discordant results. Under certain circumstances they seem to be wholly insoluble in the acid, while at other times they are decomposed completely, and partly taken into solution.

By availing myself of the solubility of the sulphids of tin in oxalic acid, I have been enabled to separate tin perfectly from arsenic and molydenum, and almost perfectly from antimony. When only arsenic and antimony are to be separated from tin, I find it best to proceed as follows: to the solution containing the three metals, this solution being prepared in the usual manner for the precipitation of the sulphids, I add oxalic acid in the proportion of about twenty grams of the reagent for every gram of tin, taking care to have the whole so concentrated that the acid will crystallize out in the cold. I then heat to boiling, and pass in sulphuretted hydrogen for about twenty minutes. No precipitate appears at first, but as soon as the liquid is saturated with the gas, the sulphids of arsenic and antimony begin to fall, and in a very few moments are completely thrown down. Then, as usual, the whole should be allowed to stand about half an hour in a warm place before filtering. Every trace of arsenic and antimony is precipitated, so that in the filtrate from the sulphids neither of these metals can be discovered by Marsh's test, nor can any antimony stain be produced with zinc upon platinum. I have carefully experimented to learn whether oxalic acid could interfere with either of these tests, and find that it has not the slightest influence upon them. The sulphid of arsenic is absolutely free from tin, but the antimony always carries down a minute trace of that metal with it. This trace, however, if the operation has been carefully performed, can scarcely be detected, and generally may be ignored with safety. If, however, the greatest accuracy is desired, it may be well to redissolve the sulphid of antimony in an alkaline sulphid, decompose the solution with an excess of oxalic acid, boil with a little strong sulphydric acid water, filter, and add the filtrate to the tin solution previously obtained.

To separate tin from molybdenum, owing to the difficulty of precipitating the latter metal with H_2S, I have been obliged to slightly vary my process. I find that by adding an alkaline sulphid in excess to a solution containing a molybdate, then decomposing the sulphur salt formed with a considerable quantity of dilute chlorhydric acid, and allowing the whole to stand over night in a warm place, every trace of molybdenum is precipitated. The sulphid thus obtained can be easily washed with a mixture of dilute chlorhydric acid and ammonic chlorid. If now, by this process we throw down tin and molybdenum together, every trace of the former metal may be dissolved out by boiling the mixed sulphids for about three fourths of an hour with oxalic acid in the proportions which I have already given.

It is best to have present in the solution, while boiling, a little dilute chlorhydric acid.

If antimony also is contained in the mixture, it is necessary, just before ceasing to boil, to add to the solution an equal volume of strong sulphydric acid water, to reprecipitate any of that metal which may have gone into solution. Upon filtering no molybdenum can be detected in the filtrate by any ordinary tests, and the molybdic sulphid is absolutely free from tin. In all these cases it is assumed that the tin is in the form of a stannic compound. It must be borne in mind that the lower sulphid of this metal is converted by the acid into an oxalate insoluble in water. But as the latter dissolves to an almost unlimited extent in dilute HCl, its formation need not interfere with an analysis.

Since the presence of oxalic acid interferes somewhat with the complete precipitation of tin by ordinary methods, I was subjected to some trouble in finding a process for determining that metal after the separation. At last I found it could be thrown down as follows; the solution, after being rendered slightly alkaline with ammonia, is mixed with enough ammonic sulphid to redissolve the precipitate at first formed, an excess of *acetic* acid is added, and the whole allowed to rest several hours in a warm place. *Acetic* acid must be used, for stronger acids would be liable to set free some of the oxalic to redissolve the tin. The precipitate which at first varies from white to pale yellow, rapidly darkens in color, and seemingly consists of a mixture of oxyd and sulphid of tin. It should be washed with a solution of ammonic nitrate, and, after ignition, is weighed as SnO_2. In two successive experiments, in which I mixed a weighed quantity of tin with unknown proportions of arsenic and antimony, I received of the tin, after making my separation, respectively 99·93 and 99·57 per cents. The loss in the second case was due to my not having allowed the tin precipitate to settle sufficiently long before filtering, in other words, to incomplete precipitation.

The arsenic and antimony, being in the form of sulphids, may be estimated by any of the ordinary methods. They may be best separated by Bunsen's process with sulphurous acid, which, though far from perfect, is superior to all others. Lenssen's method, in which the arsenic is precipitated from the sulphur solution of the two metals as ammonia-magnesian arsenate, is worthless.

A couple of years ago I made a few experiments upon indirectly determining the proportions of tin and antimony in alloys of the two metals. I oxydized a weighed quantity of the alloy with nitric acid in a porcelain crucible, heated the resulting oxyds with ammonic nitrate, and then, regarding the tin as converted into SnO_2 and the antimony into Sb_2O_4, calculated the proportions of the metals from the increase in weight. This method, although by no means giving me accurate results, served very well for rough approximate determinations. I cite it here simply as an easy and convenient process for obtaining a close idea of the constitution of any alloy composed of the two metals. Possibly the method might be so modified as to give accurate determinations.

ART. VII.—*Notes on the structure of the Crinoidea, Cystidea, and Blastoidea;* by E. BILLINGS, F.G.S., Palæontologist of the Geological Survey of Canada.

[Continued from this Journal, II, vol. xlviii, p. 83.]

5. *On the homologies of the respiratory organs of the Palæozoic and recent Echinoderms, and on the "Convoluted Plate" of the Crinoidea.*

IN a former note I have advanced the opinion that:—"The grooves on the ventral disc of *Cyathocrinus* and, also, the internal "*convoluted plate*" of the Palæozoic Crinoids, with the tubes radiating therefrom, belong to the respiratory and, perhaps, in part, to the circulatory systems—not to the digestive system. The convoluted plate with its thickened border seems to foreshadow the "œsophageal circular canal" with a pendant madreporic apparatus as in the Holothuridea." (This Journal, II, vol. xlviii, p. 73). I should have referred it to the madreporic system of the existing Echinodermata in general, instead of to that of the Holothuridea in particular. At the time the note was written I had in view the madreporic sack of *Holothuria* which, as will be shown further on, most resembles in form that of *Actinocrinus.* The figures and descriptions, which follow, are intended to show the gradual passage or conversion of the respiratory organs of the *Cystidea*, *Blastoidea* and *Palæocrinoidea* into the ambulacral canal system of the recent echinoderms, and that as the convoluted plates of the former have the same structure and connections as the madreporic sacks and tubes or sand canals of the latter, they are, most probably, all the homologues of each other.

Among the Cystideans we find several genera, such as *Cryptocrinites*, *Malocystites*, *Trochocystites*, and apparently some others, whose test is totally destitute of respiratory pores, being composed of simple, solid plates like those of the ordinary Crinoidea. In a second group of genera, among which may be enumerated *Caryocystites*, *Echinosphærites*, *Palæocystites* and *Protocystites*,

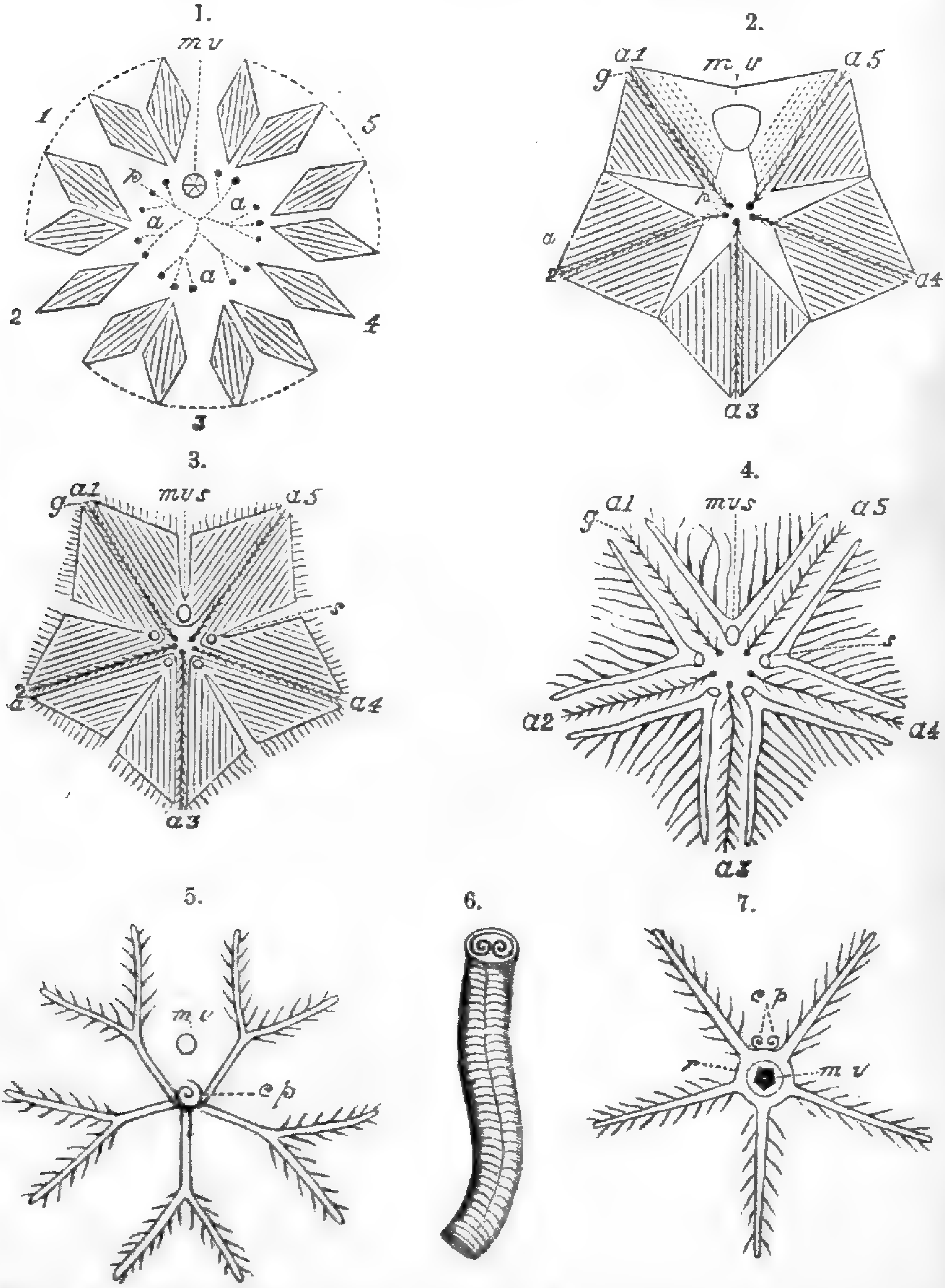


Fig. 1. The upper part of *Caryocrinus ornatus*, the test being removed in order to show the internal structure of the fourteen hydrospires that surround the summit. The parallel lines represent the flat tubes. The other figures exhibit the modifications which the hydrospires undergo in passing through:— 2. *Codaster*. 3. *Pentremites* with broad ambulacra. 4. *Pentremites* with single tubes. 5. *Palæozoic Crinoids* with a convoluted plate attached to the centre of radiation. 6. Sand canal or madreporic tube of a starfish inclosing a doubly convoluted plate. 7. Ambulacral canals of a starfish with the doubly convoluted plate of the sand canal attached to the œsophageal ring. The following letters have the same reference in all the figures in which they occur: *a*, an arm or ambulacrum; *m v*, mouth and vent combined in a single aperture; *m v s*, mouth, vent and spiracle; *g*, ambulacral groove; *p*, ovarian pore; *s*, spiracle; *c p*, convoluted plate; *r*, œsophageal ring.

the whole of the external integument seems to have been respiratory, as all, or nearly all, of the plates of which it is composed, are more or less occupied by variously arranged, poriferous or tubular structures. The Cystideans of these two groups hold the lowest rank of all those known. In their general structure they are mere sacks of a globular, ovate or, (as in the case of *Trochocystites*) flattened form. Their test consists of an indefinite number of plates without any radiated arrangement. They were also, according to our present knowledge, the first to make their appearance, two of the genera, *Trochocystites* and *Eocystites*, having been discovered in the primordial zone. No other echinoderms have been found in rocks of so ancient a date.

Next in order may be placed those genera whose test is composed of a definite number of plates, which have, to some extent, a quinary arrangement. Thus, *Glyptocystites*, *Echinoencrinites*, *Apiocystites* and several others, have each four series of calycine plates, of which there are four plates in the basal and five in each of the other three series. The respiratory areas or hydrospires are reduced in number—ten to thirteen in *Glyptocystites* and three in most of the other genera of the group. Neither in the plates nor in the hydrospires is there exhibited any tendency to a radiated arrangement. The most ancient genus of this family is *Glyptocystites*, which first appears in the Chazy limestone and seems to have become extinct in the Trenton. The other genera occur in various horizons between the Chazy and the Devonian.

In the genera *Hemicosmites* and *Caryocrinus* the hydrospires in the upper part of the test converge toward, but do not reach, the central point of the apex, thus forming the commencement of that concentration and complete radiation which is exhibited in the ambulacral canal system of the higher echinoderms. In a former note (this Jour., II, xlviii, p. 77,) it is pointed out that *Caryocrinus* has thirty hydrospires,—ten at the base with their longer diagonals vertical,—a zone of six round the middle with their diagonals horizontal and a third band of fourteen around the upper part of the fossil. These latter are represented in fig. 1, as if spread out on a plane surface. On consulting this figure it will be seen that the flat tubes of the hydrospires, represented by the parallel lines, all converge toward the central point from which the dotted lines radiate. This point is the position of the mouth in the recent echinoderms, but in *Caryocrinus* it is occupied by a large solid imperforate plate. The hydrospires are arranged in five groups. Commencing at *m v* and going round by 1, 2, &c., there are four in the first group; one in the second; four in the third; one in the fourth and four in the fifth. These five groups represent the five ambulacral canals of the recent echinoderms. In the specimen from which this diagram was constructed there are the bases of fifteen free arms to be seen situated at the outer extremities of the dotted lines. At the base of each arm there is a small pore, *p*, which I believe to have been exclusively ovarian in its function. The hydrospires have no connection whatever with the arms and are, moreover, all of them entirely separated from each other. If then they represent the ambulacral system of the recent echinoderms, it is quite certain that that system was at first, (or in the undeveloped stage in which it existed in the Cystidea,) destitute of the œsophageal ring.

In *Codaster* a further concentration of the respiratory organs is exhibited. There are here only five hydrospires and they are all confined to the circle around the apex. Two of them are incomplete in order to make room for the large mouth and vent (*m v*, fig. 2.) They are each divided into two halves by an arm, *a*1, *a*2, &c. They are only connected with the arms to this extent, that these latter lie back upon them. The arms are provided with pinnulæ but it is not at all certain that they (the pinnulæ) were in any direct communication with the hydrospires. It is evident that *in all the Cystidea*, (and in none is it more obvious than in *Caryocrinus*), there was no connection between the hydrospires and the pinnulæ. The main difference (so far as regards the evidence of the presence or absence of such a connection) between *Caryocrinus* and *Codaster*, consists in this, that in the former the arms are erect and do not touch the hydrospires, whereas in the latter they are recumbent and lie back upon them. Each of the arms of *Codaster* has a fine ambulacral groove and all of the grooves terminate in a single central aperture. But as this aperture was covered over by a thin plated integument, as in the Blastoidea, I have not shown it in the diagram, but only the five pores, *p*.

No one who compares a *Codaster* with a *Pentremites* (the internal structure of the latter being visible) can doubt that the hydrospires of the two genera are perfectly homologous organs. If we grind off the test of a species of the latter genus, selecting one for the purpose which has broad petaloid ambulacra such as those of *P. Schultzii*, the structure exposed will be that represented in the diagram, fig. 3. In *Pentremites* as in *Codaster*, the five hydrospires are divided into ten equal parts by the five rays, *a*1, *a*2, &c. In *Codaster* these ten parts remain entirely separate from each other, but in *Pentremites* they are re-united in pairs, the two in each interradial space, being so connected, at their inner angles, that their internal cavities open out to the exterior through a single orifice or spiracle (*s*, figs. 3 and 4). This is best shown in fig. 4, intended to represent the structure of *P. ellepticus* (Sowerby) as described by Mr. Rofe, Geol. Mag., vol. ii, p. 249. In this species the hydrospires instead of being formed of broad sacks, with a number of folds on one side, consist of ten simple cylindrical tubes connected together in five pairs. The only difference between the structure of fig. 3 and fig. 4 is in the width of the tubes and in the absence of folds in the latter. These two forms are moreover connected by intermediate grades. Species with 11, 10, 8, 6, 5, 4 and 2 folds being known, there is thus established a gradual transition from the broad petaloid form to the single cylindrical tube.

Between the *Cystidea* and the *Blastoidea* the most important changes are, that in the latter the hydrospires become connected in pairs, and, also, are brought into direct communication with the pinnulæ. In the Palæozoic Crinoidea (or at least in many of them) concentration is carried one step further forward, the five pairs of hydrospires being here all connected together at the centre as in fig. 5. There is as yet no œsophageal ring, (as I understand it) but in its place the convoluted plate described in the excellent papers of Messrs. Meek and Worthen This organ, according to the authors, consists of a convoluted plate, resembling in form the shell of a *Bulla* or *Scaphander*. It is situated within the body of the Crinoid with its longer axis vertical and the upper end just under the centre of the ventral disc. Its lower extremity approaches but does not quite touch the bottom of the visceral cavity. Its walls are composed of minute polygonal plates or of an extremely delicate network of anastomosing fibres. The five ambulacral canals are attached to the upper extremity, radiate outward to the walls of the cup and are seen to pass through the ambulacral orifices outward into the grooves of the arms. (Ante, vol. xlviii, p. 31.)

The ambulacral canals of the Crinoidea are, for the greater part, respiratory in their function. They are, however, as most naturalists who have studied their structure will admit, truly the homologues of those of the Echinodermata in general. In the higher orders of this class the canals are usually more specialized than they are in the lower; being provided with prehensive or locomotive organs. In all of the existing orders, including the recent Crinoidea, we find an œsophageal ring.

To this organ, which is only a continuation of the canals, are attached the madreporic appendages. These consist of small sacks or slender tubes varying greatly in form and number in the different genera. That of the Starfish *Asteracanthion rubens* is thus described by Prof. E. Forbes. "On the dorsal surface is seen a wart-like striated body placed laterally between two of the rays: this is the *madreporiform tubercle or nucleus.* When the animal is cut open, there is seen a curved calcareous column running obliquely from the tubercle to the plates surrounding the mouth; Dr. Sharpey says it opens by a narrow orifice into the circular vessel. It is connected by a membrane with one side of the animal, and is itself invested with a pretty strong skin, which is covered with vibratile cilia. Its form is that of a plate rolled in at the margins till they meet. It feels gritty as if full of sand. When we examine it with the microscope we find it to consist of minute calcareous plates, which are united into plates or joints, so that when the investing membrane is removed it has the appearance of a jointed column. Professor Ehrenberg remarked the former structure, Dr. Sharpey the latter: they are both right. Both structures may be seen in the column of the common cross-fish." (Forbes, British Starfishes, p. 73.)

In Prof. Joh. Müller's work, "Uber den bau der Echinodermen," several forms of the madreporic appendages of the different groups of the recent Echinodermata are described. In general they are composed of a soft or moderately hard skin consisting of a minute tissue of calcareous fibres, or of small polygonal plates. The walls are also, sometimes, minutely poriferous. In all the Holothurians the madreporic organ is a sack attached by one of its ends to the œsophageal canal, the other extremity hanging freely down into the perivisceral cavity, not connected with the opposite body wall as is the sand canal of the starfishes. (Op. cit., p. 84.) In its consisting of a convoluted plate the madreporic organ of *Actinocrinus*, therefore, agrees with that of the starfishes, while in its being only attached at one extremity it resembles that of the Holothurians.

The convoluted plate of the Palæozoic Crinoids and the madreporic sacks and tubes (or sand canals) of the recent Echinoderms, therefore, all agree in the following respects:—

1. They have the same general structure.
2. They are all appendages of the ambulacral system.
3. They are all attached to the same part of the system, that is to say, to the central point from which the canals radiate.

The above seems to me sufficient to make out at least a good *prima facie* case for the position I have assumed. When among the petrified remains of an extinct animal, we find an organ which has the same general form and structure, as has one that occurs in an existing species of the same zoological group, we may, with much probability of being correct in our opinion, conclude that the two are homologous, even although we may not be able positively to see how that of the fossil is connected with any other part. But when, as in this instance, we can actually see that it is an appendage of another organ, or system of organs rather, which is known to be the homologue of the part with which that of the existing species is always correlated, we have evidence of a very high order on which to ground a conclusion. By no other mode of reasoning can we prove that the column of an *Actinocrinus* is the homologue of that of *Pentacrinus caput Medusæ.*

In an important paper entitled "Remarks on the Blastoidea, with descriptions of New Species" which Meek and Worthen have kindly sent me, the authors, in their comments upon my views, state that:—

> "In regard to the internal convoluted organ seen in so many of the *Actinocridæ* belonging to the respiratory instead of the digestive system, we would remark that its large size seems to us a strong objection to such a conclusion. In many instances it so nearly fills the whole internal cavity that there would appear to be entirely inadequate space left for an organ like a digestive sack, outside of it, while the volutions within would preclude the presence of an independent digestive sack there. In addition to this, the entire absence, so far as we can ascertain, of any analogous, internal respiratory organ in the whole range of the recent *Echinodermata*, including the existing Crinoids, would appear to be against the conclusion that this is such, unless we adopt the conclusion of Dujardin and Hupé, that the Palæozoic Crinoids had no internal digestive organs, and were nourished by absorption over the whole surface. We should certainly think it far more probable that this spiral organ is the digestive sack, than a part of a respiratory apparatus."

The objection here advanced does not appear to me to be a strong one. In many of the lower animals the digestive organs are of inconsiderable size in proportion to the whole bulk. In the Brachiopoda, for instance, the spiral ciliated arms fill nearly the whole of the internal cavity, the digestive sack being very small and occupying only a limited space near the hinge. These arms, although not the homologues of the convoluted plates of the Palæozoic Crinoids, have a strong resemblance to them, and are, moreover, at least to some extent, subservient to respiration. They are certainly not digestive sacks. In the recent echinoderms the intestine is usually a slender tube with one or more curves between the mouth and the anus. It fills only a small part of the cavity of the body, the remainder being occupied mostly by the chylaqueous fluid, which is constantly in motion and undergoing æration, through the agency of various organs, such as the respiratory tree and branchial cirrhi of the Holothuridea, the dorsal tubuli of the Asteridæ and the ambulacral systems of canals of the class generally. In no division of the animal kingdom do the respiratory organs occupy a larger proportion of the whole bulk than they do in the Echinodermata. The great size which the convoluted plate attains in some of the Crinoids is, therefore, rather more in favor of its being a respiratory than a digestive organ.

Professor Wyville Thomson says that inside of the cavity of the stomach of the recent Crinoid, *Antedon rosaceus*, there is a spiral series of glandular folds which he supposes to be a rudimentary liver. (Phil. Trans. R. S., 1865, p. 525). It is barely possible that the convoluted plate may represent this organ. At present I think it does not.

I believe that the reason why the convoluted plate attained a greater proportional size in the Palæozoic Crinoids, than do the sand canals of the recent echinoderms, is that the function of the system of canals (of which they are all appendages,) was at first mostly respiratory, whereas in the greater number of the existing groups, it is more or less prehensive or locomotive, or both.

[To be continued.]

ART. VIII.—*Upon a new Spectroscope, with Contributions to the Spectral Analysis of the Stars;* by DR. J. C. F. ZÖLLNER.*

STELLAR spectrum analysis, in addition to its revelations concerning the physical constitution of the heavenly bodies, has begun most recently to claim attention in an increasing degree in another no less interesting direction. With the aid of this method the prospect is presented of proving, and under favorable circumstances also of measuring, what influence is exerted on the lines of the spectrum of a star by the components of the relative motion of the earth and star along the line uniting the two bodies.

A single consideration shows that effects which two separated bodies exert upon one another by means of a periodical impulse of a limited rapidity of propagation must be modified by a continual change of the distance separating them. It is Doppler's merit to have first, in the year 1841, recognized the necessity of this influence,† although the conclusions which he derived from it with respect to the color of the stars must be acknowledged as incorrect by reason of a disregard of the invisible parts of the spectrum.

With reference to sound this influence was proved to be conformable to the demands of theory by numerous experiments of Ballot, Mach and others.

On the contrary with reference to light it has not been possible hitherto to establish by observation a trustworthy value (sicher nachweisbare Grösser) of this influence, because even the cosmical movements, which are the greatest at our disposal for this object, are very small in comparison with the rapidity of the propagation of light.

The great improvement however, which optical instruments for the observ tion of spectra have experienced since the dis-

* From the Proceedings of the Royal Society of Sciences of Saxony at Leipzig, Session of Feb. 6, 1869. Translated by A. N. Skinner, assistant at the Dearborn Observatory, Chicago, Illinois.

† Doppler, "On the colored light of double stars and of some other stars of the heavens." Transactions of the Bohemian Society of Sciences, vol. ii, (1841–42) p. 465–482.

covery of spectrum analysis, presents the prospect of demonstrating this influence by the spectra of the stars. According to theory this influence must show itself in a small displacement of the lines of the spectrum. For example, for a mean velocity of the earth of four German miles per second, this displacement would amount to the tenth part of the distance separating the two sodium lines. This value which is obtained in a very simple way from the velocity of light and the undulation-time of the rays corresponding to the sodium lines, has only quite lately been derived again by J. C. Maxwell, in agreement with earlier computations by F. Eisenlohr* and others.

The amount to be observed of the displacement appeared, however, to Maxwell to be so small, that he closed his considerations concerning this (having reference to the spectroscope hitherto constructed and the method of determining the position of the lines), with the remark: "It cannot be determined by spectroscopic observations with our present instruments, and need not be considered in the discussion of our observations."†

Huggins nevertheless in his most recent memoir,‡ of which the above mentioned investigations of Maxwell are an integral part, attempted the solution of the problem in question by the use of a spectroscope with no less than five prisms, of which two are Amici's, with two flint and three crown-glass prisms.

The diminution of the light caused by so great a number of prisms permits, however, the observation of only the brightest stars. Huggins indeed even confined himself to the communication of his results from observations on Sirius, and he believed here that he found a small displacement of the line F in comparison with the bright hydrogen line produced by a Geissler's tube. The direction and amount of the displacement would indicate an increase in the distance between the earth and Sirius, and this with a velocity of 41·1 English miles per second.

If we eliminate the component of the earth's movement, which at the time of observation amounted to 12 English miles, the resulting velocity with which the sun and Sirius are moving from one another would be 29·4 English miles, or about 6·5 German miles.

Huggins himself regards this result as one affected by great probable error, an error caused partly by the great weakening of the light, already mentioned, from numerous prisms, and partly by the difficulty of comparing the coincidences of the bright lines from terrestrial sources of light with the analogous dark lines of stellar spectra. The latter have sometimes a dif-

* Heidelberg Transactions of the Phys. Med. Soc., vol. iii, p. 190.
† Phil. Trans., 1868, p. 532. ‡ Ibid., p. 535.

ferent appearance; for example, they are blurred on the edge and of different breadth, as is precisely the case with the line F in the spectrum of Sirius.

The most essential of these difficulties, which have hitherto opposed a definite solution of the problem in question, I believe that I have successfully overcome, by a new construction of the spectroscope, the first example of which I have the honor to exhibit here to the Royal Society.

The arrangement is in essentials the following. The line of light produced by a slit, or a cylindrical lens, lies in the focus of a lens which as in all spectroscopes renders parallel the rays to be dispersed. Then the rays pass through two Amici's direct-vision prism-systems of excellent quality, which I obtained from the optical establishment of Merz in Munich.

These are fastened to one another in such a manner that though each passes one half of the pencil of rays proceeding from the collimator object-glass, and also so that the refracting angles lie on opposite sides. In this way the collected pencil of rays will be dispersed in the two spectra in an opposite direction. The object-glass of the observing telescope, which unites the rays again to an image, is perpendicular to the refracting angles of the prisms placed horizontally, and as in the heliometer, is divided; each of the two halves can be moved micrometrically both parallel to the line of section and perpendicular to it. By means of this we can bring the lines of one spectrum into coincidence with those of the other, and also place the spectra in immediate juxtaposition instead of superposing them, so that one spectrum moves by the other like a vernier, or we can superpose them only partially. By means of this construction not only is the delicate principle of double-images rendered available for the determination of any change whatever in the position of the lines of the spectrum, but *any such change is also doubled*, since its influence appears in the two spectra in an opposite sense.

The principal of the reversion of spectra which lies at the foundation of the instrument described, on account of which I venture to propose for it the name "REVERSION SPECTROSCOPE," can be introduced without using Amici's systems of prisms. It is only needed to reverse one part of the pencil of rays proceeding from a common prism by reflection on a mirror or prism, and then to observe the united pencil of rays exactly as above with a telescope furnished with a divided object-glass. Furthermore, this principle renders the simultaneous introduction of artificial sources of light for the investigation of small changes of refrangibility wholly unnecessary, and permits the perception and measurement of these changes, by means of the changes in position of objects completely similar in kind.

The series of measurements which was carried out both on the dark D line of the solar spectrum, and also on the bright sodium lines of a candle flame impregnated with common salt, (and these I venture to add here to show the working power of the instrument), authorizes the hope, that with the aid of this spectroscope we shall succeed not only in perceiving the influence of the earth's movement, but also in determining it quantitatively with such accuracy as appears desirable for an approximate (vorlaüfig) control of theoretical conclusions.

The numbers cited denote the parts of the micrometer-screw, and refer to the distance between the two sodium lines:

Sodium flame.	Sun.
49·5	49·5
50·5	51·5
53·0	48·1
49·5	48·9
50·6±0·6	49·6±0·5

In the following series of observations the reversion spectroscope was furnished, not only with another micrometer-screw with a somewhat coarser thread, but also with two other systems of prisms whose dispersion in the region of the sodium line is 1·77 times greater than that of the systems used for the above measurements. Likewise the old achromatic object-glasses of the collimator and the observing telescope were replaced by unachromatic ones, by which not only nothing was lost in sharpness of the images, but, as was designed, an advantage was gained in clearness and distinctness by increasing the intensity of light.

Sun.

Screw divisions.	Deviation from mean.
67·1	−0·8
69·4	+1·5
68·4	+0·5
67·9	0·0
66·6	−1·3
66·1	−1·8
68·2	+0·3
68·0	+0·1
69·6	+1·7
Mean 67·9±0·3	

According to this, the interval between the two D lines was accurately determined, with a probable error of $\frac{1}{226}$ of its value. But in accordance with facts previously presented, a change of the distance separating the source of light and the spectroscope, with a velocity of four German miles per second, will effect a corresponding displacement of the lines of the two spectra, to the amount of $\frac{1}{5}$ of the interval of the D lines, a quantity which is also about forty times greater than the probable error found above for the mean of nine readings.

If, therefore, in the observation of stellar spectra, a sufficient amount of light can be used, it can be definitely determined in the way stated, whether the expected displacement of the lines of the spectrum occurs or not. In reference to the intensity of light required, I venture to remark, that, for these observations, an unachromatic lens* of one Paris foot in aperture and six feet focal length is at our disposal; its cone of rays one inch from the focus is acted upon by a suitable concave meniscus of flint-glass, and, freed thus as much as possible from spherical and chromatic aberration, is directed to the slit of the spectroscope. I feel that I should here especially point out the fact, that, in the use of a slit, the achromatism of the optical image, for the observation of its spectrum, (especially of individual parts of it), is unessential, and consequently the construction indicated here must claim the important preference of great cheapness in comparison with those with achromatics of strong light. Evidently this advantage must be given up in those cases, where, as in double stars, the desideratum is the sharpest possible separation of the objects under investigation.

I may be permitted perhaps to make some remarks upon problems and methods which refer to spectrum observations on the sun and with which I am at present employed.

The sun possesses a velocity of rotation, by virtue of which a point on its equator moves with a velocity of about 0·25 German mile. If, therefore, with the aid of a heliometer, or in any other way, we produce a double image of the sun, and by a suitable arrangement bring into contact two points of the equatorial limb, then at the point of contact, parts of the sun's surface border upon one another, one of which approaches us with a velocity of the given amount, and the other recedes from us with the same velocity. From this arises a difference of velocity of the parts in contact, in the direction of the line of sight, of about half a German mile. According to previous statements such an amount of movement would cause a change of position of the sodium lines corresponding to the 80th part of the interval between them. Therefore if by combination of a sufficient number of prisms, we succeed in perceiving such a quantity, so as to measure it, we need only to bring the middle of the slit into the line joining the two centers of the images of the sun which are tangent to each other in order to see the two spectra of the sun's limbs which are thus in contact, close together in the field of view, and then, under the most favorable relations, to observe the displacement in question. In this way then the position of the solar equator, and, in case of the

* Made in the optical establishment of H. Schroeder in Hamburg.

practicability of measurements, the velocity of rotation in various heliographic latitudes would be determined, which would be of the greatest interest with reference to the opinions pronounced most recently on this point.

But even without regard to a quantitave determination of the phenomenon in question, by means of a proof of it only qualitative, even a simple means would be found of separating *all the lines which arise from absorption in the earth's atmosphere, from those which owe their origin to the solar atmosphere,* since the displacement in question could evidently extend only to the latter.

Another subject for the investigation of spectrum analysis is the protuberances. As is well known, Lockyer and Janssen were the first who succeeded, independently of a total eclipse of the sun, in observing the spectra of these forms, which consist of three bright lines.

At the present time it is the object of most earnest endeavor to discover any methods which permit not only the observation of these lines but also simultaneously of the entire shape of the protuberance.

The length of the bright lines corresponds to the magnitude of the dimension of the protuberance concerned, which occurs in the direction of the slit. Consequently if we bring the slit successively into different positions so that it cuts the protuberance in as many directions, then we are able to construct the form of the image observed, as Lockyer has already done. Thereupon Janssen has proposed the construction of a rotating spectroscope, in order thus with a sufficient rapidity of rotation to survey rapidly the form of the whole protuberance during the continuance of the impression of light.

Leaving out of consideration the mechanical difficulties of such a rotating spectroscope in which one of the bright protuberance lines must lie accurately in the axis of rotation, the design in view can be accomplished in a simpler and more complete manner by an oscillation of the slit perpendicular to its direction. In this way the protuberance could be observed in three differently colored images corresponding to the three different lines of its spectrum.

In this method, with a movable slit, the changes of brightness, through which the protuberance passes from its base, will however be considerably weakened, in proportion to the length of the path passed over by the slit; in the rotating spectroscope especially, the brightness of the protuberance itself would be weakened from the center of rotation out to the edge, and consequently the observation of the natural relations of the brightness of the image would be frustrated.

For this reason I have in view the introduction of another very simple method for the attainment of the object in question, of the practicability of which I am already convinced by experiments on terrestrial sources of light, to be described more in detail below. The principles on which this method depends are the following:

1. The apparent brightness (glanz, *claritas visa*)* of a strip of a protuberance is independent of the aperture of the slit under the hypothesis that it continues to have a perceptible breadth on the retina.

2. The brightness of the superposed spectrum increases proportionally to the width of the slit.

3. With an oscillating or rotating slit, the brightness of the superposed spectrum remains unchanged, while that of the image of the protuberance arising from the permanence of the impressions of light, diminishes on the other hand in accordance with a law depending on the number and duration of the excitations of the point of the retina concerned, which occur in a unit of time, and also upon the refrangibility of the strip of the protuberance observed.

If, for simplicity's sake, we suppose that the entire surface, over which the slit moves in its rotation or oscillation, is filled up by the protuberance, and if we suppose also that the intensity of the image arising, is inversely proportional to that surface, (corresponding to a uniform extension, over the surface, of the light passing through the slit), then under the assumption of the above three propositions, the relation of intensity between back-ground and protuberance, would remain the same; and we may

First, reduce the brightness of the image of the protuberance by an *oscillation* of the slit, and by this leave unchanged the brightness of the superposed spectrum (by 2); or we may

Secondly, open the slit *unmoved* so far that its aperture extends at once over the space, which in the first case the oscillation extended over. In this (by 1) the apparent brightness of the protuberance remains unchanged, but that of the back-ground is increased in the same ratio that it was previously weakened. Consequently under the suppositions made, the designed object would be accomplished much more simply in the second way, if, because of its blinding, care is continually exercised that the intense light of the real body of the sun should not penetrate the slit.

The slit need be opened only just so far that the protuberance or a part of it may appear in the opening. A suitable weakening of the entire field of view must be provided for, by means of polarizing or absorbing media, which are to be placed before the eye-piece, in order that the relative intensity between the

* Lambert, Photometria, etc. §§ 36 and 37.

protuberance and the superposed spectrum may be permitted to stand out as strongly as possible to the perception.

Led by these conclusions, I have sought, with the aid of terrestrial sources of light, to realize the conditions under which the protuberances are visible, in order, in this way, to test both methods and to convince myself of their practicability. For the better comprehension of the described experiments, let the following remarks first be premised.

The reason why the protuberances are invisible under ordinary circumstances, by screening off the intense image of the sun to the edge, lies in the strongly illuminated part of our atmosphere covering the image of the protuberance. In a total eclipse of the sun this superposed light is weakened to such an extent, that then the intensely illuminated protuberances raise themselves from the illuminated parts of the corona.

We can make an approximate estimate of the amount of the reduction of the diffused light of our atmosphere required for this, if we assume the mean illumination of the atmosphere in a total eclipse equal to that of a mean full moon. According to my photometric measurements* this illumination is 618000 times weaker than that produced by the sun; consequently then the selective absorption of colored media must stand in a similar relation in reference to the homogeneous light of protuberances, if we wish to make the protuberances visible in this way without dispersion as is generally sought at the present time.

On the contrary the possibility of accomplishing this end, with the aid of the prism by the dispersion of the superposed atmospheric light, depends essentially upon the circumstance, that this light is composed of rays of all degrees of refrangibility, while that of the protuberances, however, is composed of only three homogeneous assemblages of rays.

The superposition of an unhomogeneous mass of light upon a body shining with homogeneous light and limited by sharp boundaries, I have accomplished artificially, in the following way. The wick of an alcohol flame was impregnated with chlorid of sodium and chlorid of lithium. At a distance of 18 feet before this flame, a piece of plate glass was so set, at an angle of 45° to the direction of the observation, that the reflected image of a petroleum flame at one side covered the faintly shining alcohol flame, and, by reason of its much greater intensity, rendered it completely invisible. About one foot before the reflecting plate of glass, was situated a small lens of six inches focus, which directed a small image of the alcohol flame to the slit of the spectroscope. The latter was fastened to the end of a spring ten inches long, by means of which it could be put in oscillation of sufficient magnitude for about five minutes by

* Photometrische Untersuchungen, etc., p. 105, fol., Leipsic, 1865.

first removing it from its place of equilibrium and then releasing it. Next then, the aperture of the slit was so far decreased, that, with the slit at rest, the double line D and, proportionally faint, the lithium line also appeared sharply defined in the field.

As soon as the slit was put in oscillation, these lines transformed themselves into sharp images of the alcohol flame, of which the two sodium images covered about half. The apparent brightness of these three images was much less than that of the bright lines, and in consequence of this also their relief from the diffusely illuminated spectrum ground was in the same ratio less distinct than that of the lines with the slit in a state of rest.

When now I made use of the second of the above proposed methods, and opened the unmoved slit so far that the little image of the alcohol flame was only just contained by the rectangular aperture of the slit, I was surprised by a far greater delicacy and distinctness, with which the image of the flame relieved itself from the diffusely illuminated spectrum ground. Consequently the above reduction of the apparent brilliancy of the protuberance with an oscillating slit, assumed in the theoretical discussion to be in accordance with a simple law, appeared quite strongly to incline our favor to the method last employed.

I remark here that for this experiment only one of the above mentioned new prisms was employed. But it is evident that with an additional dispersion, the diminution of the superposed unhomogeneous light can be increased at pleasure.

As may be seen, no difficulty in principle stands in the way of the application of this method to the protuberances of the sun.* Practical success, however, is dependent essentially on this, whether a sufficiently strong dispersion of light can be obtained for the actual relation of intensity between the homogeneous light of the protuberances and of the superposed light of the atmosphere. If, however, we are authorized to conclude upon a very considerable relative brilliancy of the protuberances, from the intensity and distinctness with which their lines, especially the middle one, appear,—of which I am convinced by an actual inspection on the 24th of December of the past year at the observatory at Berlin,—then the means at my command at present consisting of four excellent systems of prisms must indeed be sufficient to solve satisfactorily in the way here proposed the problem of the visibility of the protuberances.

Supplement.

According to a communication by letter, lately received from Dr. Schallen at Cologne, Mr. Lockyer also has succeeded in

* On account of an incomplete arrangement of the instrument demanded I have till now been obliged to refrain from an actual trial of this method on the sun.

observing the solar protuberances in their whole extent, according to the method developed by me in the above communication. By this communication, Mr. Lockyer has employed a spectroscope with *seven* prisms, and has communicated his results in a report held in the Royal Institution, which ought to appear in print June 15th. Since I have neither received this report up to the present time, nor even learned any details concerning Mr. Lockyer's results, it may be permitted me here to communicate the following in regard to the procedure employed by me.

The spectroscope, which has been made according to my designs in the optical establishment of Mr. Fauber in Leipsic, possesses one excellent direct vision prism by Merz. The spectroscope was fastened in a suitable way to the six feet refractor of this observatory. The height of the slit amounted to 6′ 20″ of arc, and the aperture varied with the height and magnitude of the protuberance observed. And here let it be remarked that it is most advantageous in observing to bring the length of the slit tangent to the sun's limb. By this plan on the one hand a greater segment of the sun's limb is surveyed at one view, and on the other the advantage is gained of determining with great accuracy the position angle of the protuberance, since the entrance of the sun's disc makes itself immediately noticeable by a flashing out of a narrow band-formed spectrum in the middle of the field of view. This point of the first flashing out can be easily brought to the place of the protuberance in question by revolving the spectroscope about its longitudinal axis, and in this case, as is readily perceived, the slit is tangent to the point of the sun's limb occupied by the protuberance. The actual place of the spectroscope can be read off on a divided circle, and this gives the position angle of the protuberance.

In order to bring individual points of the sun's limb conveniently before the slit of the spectroscope, two different methods can be employed. By one method the object-glass of the refractor is so fastened in a ring that its optical axis is inclined about 15′ to the longitudinal axis of the telescope. If this ring is revolved by the help of a screw on the telescope to be worked by the observer, the optical axis of the object-glass describes a cone of about 30′ opening, so that successively different parts of the limb come in focus before the middle of the slit. Of course the position of the slit must be varied in a corresponding way by a revolution of the spectroscope.

By the other method, which affords the advantage of an unchanged position of the slit, the rays before their union into an image are sent through a reversion-prism, so called. If this is rotated about the axis of the instrument, the image of the sun also revolves about its center and permits successively different points of the limb to fall on the slit. The angle of position is determined by the position of the reversion-prism.

The size of the sun's image in the refractor, or, in other words, the focal length of the object-glass employed, plays an important part in the whole method. It follows immediately from the theory of the method developed above, that *with the same spectroscope* the contrast between protuberance and back-ground is dependent only upon the width of the slit. Since, then, with a *constant* width of slit, the smaller the sun's image, so much a greater part of the protuberance is surveyed at once, it follows that we must not seek to accomplish the amplification of the protuberance by the sun's image, that is, with a long focus of the object-glass of the refractor, but as much as possible by the lens apparatus of the spectroscope. This can be easily accomplished by using a collimator with a relatively short focus to that of the object-glass of the refractor. Suppose, for example, we have a refractor of ten feet focus with a spectroscope attached, in which the focal length of both object-glasses are equally large. If now with this it is required to open the slit to the breadth of one millimeter in order to take in at one view a protuberance of a certain size, with an image of the sun $\frac{1}{10}$ smaller, this aperture could be reduced to $\frac{1}{10}$ of a millimeter, through which not only can the protuberance be seen in its whole extent, but also with a ten times greater contrast with the spectrum back-ground. In order now to obtain again the amplification of the protuberance *in the field of view*, which was lost by the diminution of the sun's image, the focus of the collimator need only be made ten times shorter than that of the spectroscope. To continue with the example proposed, a ten times better effect would be obtained, *giving the same optical amplification* of the protuberance *with the same prism systems*, if there is chosen in place of the ten feet refractor a telescope of only one foot focus, and for the focal distance of the collimator about two inches, and that of the observing telescope about twenty inches. The quality of the images in this is influenced very little, as far as affected by the lens system, since the defect of chromatic aberration does not enter at all on account of the homogeneity of the light of the protuberances; consequently, properly selected unachromatic lenses can be used for such combinations without any hesitation, as I have convinced myself by numerous trials. The extraordinary compactness which such instruments for the observation of the solar protuberances possess, permits a very delicate clock movement, and presents the prospect of realizing in this simple way the idea expressed already in my former communication, namely, an artificial total eclipse of the sun, of an arbitrary length, for the observation in the future of all the protuberances present on the sun's limb at the same time.

Leipsic, August 26, 1869.

ART. IX.—*Polarity and Polycephalism, an essay on Individuality;* by H. JAMES CLARK, A.B., B.S., Prof. Nat. Hist. Kentucky University; Lexington, Ky.*

WE have already, in a general work† upon the development, morphology and classification of animals, entered our protest against that theory of individuality which assumes that the medusoid genitalia of Hydromedusæ should be considered as individuals in a higher sense than the hydræ are, no matter to how low a degree of development they descend nor at how high an elevation they arrive in the complicity and differentiation of their parts. We still adhere to that protest as far as the hydræ and medusoids are related to each other; but look upon them both in a modified light in reference to their individuality. We suppose it will not be questioned that, in the main, naturalists and physiologists have always defined in their own minds, and in their teachings, the zoölogical *individual* to be a *monocephalic* being; that they have taken as their standard the most highly developed creatures of the animal kingdom, whose *oneness* and independence place them on an equal footing with man in these respects. In the discussion of late years upon the individuality of the lower, compound, colonial denizens of the water, the main points at issue have always been to determine whether a certain form was, on one hand, an *individual*, either in its highest sense (a monomeric, independent integral) or one of several interdependent individuals which constitute a colony (a polymeric integer), or, on the other hand, was an *organ*, which formed only a part of an individual, whether the latter be monomerous (as in Hybocodon and Corymorpha producing free medusæ), or polymerous (as in Coryne with free medusæ).

The possibility of a third category of individuality had not arisen in the minds of philosophic naturalists until the question of the bilaterality of the two lower grand divisions of the animal kingdom had been discussed so vigorously, and elevated to such a prominence among the theories of the day as to extend its influence even to the determination of the oneness or duality of the members of the highest of all grand divisions, and indeed the highest of all animals, man himself. Here at this point we find breaking in upon us the Teratological essays of St. Hilaire, and the more recent decisions of Wyman upon the same subject, with the strange confirmations of Lereboullet, by his discoveries of the fissigemmation of the piscine egg, and

* This is an extract from a forthcoming memoir on the anatomy and physiology of Lucernariæ.

† Mind in Nature, or the Origin of Life and the Mode of Development of Animals. New York, D. Appleton & Co. 1865.

the evolution of two heads or two tails from one center of development,—the *dualistic* tendency of the highest vertebrate emphasized by the presentation of the living, tangible reality.*

Such possibilities among the vertebrata staring us in the face could not but send the thoughts flashing back among the inferior, less determined, less differentiated organizations; and the mind's eye needed not to dwell long among the many-headed Polypi and Hydromedusæ, the Crinoidæ, Bryozoa, Ascidiadæ, Pyrosomidæ, Salpæ, &c., before discovering a multitude of more than shadowy tendencies; it became fixed upon numerous sharply and clearly established, unmistakable dualities and pluralities; all arising from one common center, the *ovum*. Had we not the problem of plural individuality solved here,—*a polycephalism—?* the diffuse vitality of the animal-egg of the lowest ranks of life outspoken in the indetermined number and localization of the subdivisions of the Polyp or Hydromedusa corporation; and even the organization itself undecided as to whether it should exemplify its oneness in a simple unit of form, as in the *pseudoindividuum* of Bryozoa, Ascidiæ, or resolve its offices and configuration into the repetitive, multiplied sameness of the sexless and sexual *proles* of Salpæ, Tæniæ, Annelidæ and Hydromedusæ, or the excessive reiterations of the genitalia of Polypi.

The old type of monomerism, the vertebrate individual *par excellence*, has then become the modern, more than transcendental *duality*. The originals of multitudes of figures in St. Hilaire's 'Teratologie,' of the memoir of Lereboullet, and of the condensed aphoristic sketches of Wyman stand forth the real, material embodiments of the idea upon which all sentient life is founded. *Bilaterality* does not express the thought, it embraces too little; it is to be classed with antero-posteriority and dorso-ventrality, to signify the *subdominant* features of the animal architecture; features which evolve themselves as the concomitant resultants of the development of the primitive dominant which originally gave shape to *bipolar ovum*. The embryölogist, and to his thoughts the subject is most germane, reflecting upon the physical aspects of the forming egg, would naturally arrange its features in two antagonistic fields; and thereupon attempting to define their position in regard to the contour of the concrete sphere, almost inevitably would give utterance to the word *polarity*. This is the dominant, main idea of sentient life.

It is *polarity* which is evinced when the self-dispersing, self-repellant potentiality of the animal-egg lays down the right and left of the germ on opposing sides of a line; when the cephalic and caudal areas grow in opposite directions from a common point of emanation; or when the animal and vegetative

* See remarks of the author on this subject in "Mind in Nature," ut Sup., p. 85.

foundations project themselves into diametrically diverse, dorsal and ventral spaces. Each and all of these phenomena have a common point to rest upon; and they proclaim, by their mode of operation, the controlling influence of a power which, fixing itself upon that point, as it were, radiates itself through the whole organism, and disposes its several features in such a way that they all display, either in mode of evolution or by a direct connection, a polar tendency; a growing out of one pole and a dispersion toward the opposite one; features most developed and decided in configuration next the point of departure, and least developed and most diffuse and indeterminate in the opposite area; the latter always through life standing in the same relation to the former as supply does to demand, as nutrition does to the power which regulates the absorption of the nutriment.

But *bilaterality* carries with it something more than the sheer dextral and sinistral opposition of the lateral halves of the body; it is not merely the bipartition of a *unit* of form; for the distal as well as the proximal edges of these halves,—the free borders and the margins of contact—are mutually interchangeable; the former may take the place of the latter, and yet leave the apparent bipartite unit undisturbed in internal relations.

Antero-posteriority exhibits the same interchangeability as bilaterality, but, although plainly enough, not so conspicuously in a comparative, homological sense as in the physiological interplay of the functions, such as we see in the relations of the allantois to respiration in the embryo, or in the ratio of excretion of the renal organs dependent upon the degree of activity of the respiratory and perspiratory functions; or in the relation of the reproductive organs to the vocal and respiratory, when the former are in an abnormal condition, or when they change from one period of life to another, from youth to adolescence; and in many other interdependent relations familiar to the morphologist of the present day.

Bilaterality, antero-posteriority, and dorso-ventrality, the three principal *subdominants of polarity*, have a very methodical disposition, and are quite pronounced and sharply defined among the higher groups of animals,—the more seemingly *units* of organization,—but if we go to the opposite extreme of grade we shall find, among the lower classes of life, that the polaric element (like the differentiation of organization, and that of function) is in an almost elementary condition, expressing itself vaguely in the scattered heads of a branch of Coryne, or Tubularia, or Clavellina; or a little more determinately in the distichous arrangement of the hydra heads of Dynamena and Sertularia, or in the singularly stellate disposition of the zoöids of Botryllus, with their common cloacal orifice.

When, however, polymerism, in its usually accepted sense, fails, as it does step by step in the gradually rising degrees of rank, polarity gains the ascendency in point of regularity and the closer intimacy and symmetrical arrangement of the components of the organization which it holds sway over. Thus it is that two, or more, scattered, consimilar parts, or complete organizations may combine to form a seeming *one*, an apparent, bipartite or multipartite *unit*. The multiple repetition of heads among the lower polymeric kinds is here reduced to a dual repetition, and the parts condensed into one form an approximative unit, a zoölogical *individuum*, as the highest expression of unity attainable by the vertebrate *zoön*.

The duality, nay the plurality of the subdivision of the vertebrate axis, as illustrated by the embryo fishes of Lereboullet, is recalled in the diffuseness of the many hydræ of the dendritic Campanulariæ, or disguises itself under the interminable heteromorphism of the Siphonophoræ; it is polymerous but dimorphous in Salpa, or polymerous but monomorphous in the fresh water Polyzoa; temporarily a polymerous, monomorphic *individuum* in the fissigemmating Hydra, it eventually resolves itself into disconnected *pseudo-individua;* for a time polymerous but dimorphic in the annelidan Myrianida of Milne-Edwards it finally assumes the appearance of a true, self-contained *individuum* in each one of the separate, independently moving *sexual segments*, and in the original budding-stock (the direct legitimate offspring of the egg) from which they shot forth.

The thorough historian of the multifarious, so-called alternate, generations of the Acalephæ will see nothing but a generative organ in the spermatic and ovarian sacs of Hydra; and detect nothing more in the grape-like clusters about the base of the head of Clava, or in the grouped moniliform projections behind the corona of tentacles of Eudendrium. The polymerism of these organs of Eudendrium is merely, and nothing more than a repetition of the simple sac of Clava; the diversity in form is only apparent. But one step higher in complicity and our observer will find in the tentaculiferous terminations of the reproductive sacs of Thamnocnidia and Parypha a premonition of a forthcoming cephalic independence, such as is already fully exemplified in the many hydras of the polymeric, dendritic mass. A similar progression toward cephalic freedom will also be seen in the simplest generative sacs of Laomedea amphora, and L. flexuosa, &c., and rising through successive degrees of complicity to those of Gonothyrea (Laomedea) Lovenii *All*, which not only are tipped with tentaculate processes as in Parypha and Thamnocnidia, but have developed within them a series of longitudinal tubes, like those in the homologous organ of Tubularia indivisa.

Gradually and methodically the progressive steps of complication lead on, with a more and more marked separation of the genitalia from a direct relation to the general mass, or even to the hydræ in particular, whilst a consentaneous development gathers around them and brings them into immediate alliance with an envelope whose *morph* is only a slightly varied repetition of that of the hydra, but whose greater degree of complicity gives it a better claim to be ranked as the highest among the *cephalic subdivisions* of the body. But the full aim of the train of development is not divulged here; its results only exemplify a part of it in the predominance of the reproductive function and a differentiation of the nutritive cavity into distinct channels of circulation, and the subordination of a definite region of its periphery to a tentacular, prehensile office.

Step by step, however, all the elements of a complete organism are successively absorbed out of the primitive hydra-mass, and remodelled into the fashion of a medusoid; the reproductive character has become a less obtrusive feature; motion attracts attention above all others; prehension has full sway in the highly developed tentacles; and the latter point, like fingers, to the self-sustaining power of the acalephan morph in the complete organization of the longitudinal and circular chymiferous channels, opening into the receptive cavity of a highly flexible, proboscidal *manubrium*. The preliminary processes of fissigemmation are complete; the primary genesis of the *ovum, in its integrity*, is finished; the primitive stock has become differentiated into two widely diverse varieties of one morph, the *hydroid cephalism* and the *medusoid cephalism*. Such is the condition at which the hydromedusariæ of Corymorpha, Hybocodon, Ectopleura (Tubularia) Dumortierii, Pennaria, Coryne mirabilis, Margelis, Bougainvillea, and many Campanulariæ have arrived previous to the disintegration of their mass into the free *pseudo-individual medusoids*, and their less independent, contemporary homologues, the persistent *hydroid cephalisms*.

No one holding the present prevailing views in regard to individuality would find a difficulty in seeing that the members of a chain of Salpæ are so-called *individuals*, notwithstanding they are attached obliquely end to end, and *organically* connected. Now although the self-dividing worm, Myrianida for example, the so-called *asexual* stock may become, by actual separation, two individuals, apparently, viz: *sexless* and *sexual*, yet once they were more closely connected organically than the Salpæ which do not separate. Is now the closer connection of the yet unseparated asexual and sexual parts of the worm to make them less distinct individuals than those of the Salpa? It would seem so, according to the advocates of individualism;

and therefore the Myrianida, with its posterior string of six or seven consecutive sexual *buds* is a *monocephalic* individual. But in the sexless Salpa-form budding the sexual chain we have a closer parallelism with the worm than in the chain alone, in fact an identity of relation; and yet for all that we would not think of calling the stock (sexless) and the chain (sexual) together one individual, with *one* head, but rather *many* headed, or in other words a *polymeric unit or individual*, of sexual and sexless *cephalisms.* Therefore by a parity of reasoning we ought to denominate the Myrianida and its buds as a succession or series of *cephalisms.* The fact that the worm components are more in one line than in the Salpa only makes an *apparently* more individualistic body. Among tapeworms the several heads (*cephaloids*) of the *scolex* (Cœnurus) of Tænia Cœnurus are not arranged in a line end to end, but all are free anteriorly, and connected with each other posteriorly by a common body. The closer connection of the subdivisions of the annelid is only one of degree; and as to having more organs in common than the Salpa it is rather like the community of interest which the coral cephalisms have in the main trunk.

Since the sexual and sexless are necessary to make up a complete organism, i. e., vegetative and reproductive, the one a completement of the other, neither *alone* can represent the *individual* unit, or whole cycle of life: and CEPHALISM therefore is a better term to indicate the potentiality of these subdivisions to live apart, although it does not always occur (as in Corals, Bryozoa, some Campanulariæ and Tubulariæ), or when apart (as in other Tubulariæ [T. Dumortierii], Laomedeæ [Eucope diaphana, &c.,] and Salpæ, Myrianida, &c.,) meaning more or less *incomplete* individuals (pseudo-individuals) which are either mainly vegetative or mainly reproductive, as the case may be.

We look upon cephalism then, on one hand, as having a controlling influence of a low degree of independence when shared in common by the multiple heads of a coral polypidom, and, on the other hand, as attaining to the highest independence as a controlling power, when the multiple parts of a so-called compound individual separate from each other, and are singly under the influence of this power. The latter obtains when Hydra or Actinia separates its buds from itself; or when the sexual part of the annelid worm subdivides from the asexual one. Cephalism of a low degree is more readily recognized in the aggregated cephaloids of Salpa than in the undivided worm, but, unlike the latter, remain connected cephaloids (in the chain) when separated from the budding stock.

By thus dividing the body of a Hydromedusa into two parts, which shall contain, severally, the vegetative dominant (*i. e.*, *vegetative cephaloid*) and the sexual dominant, (*i. e.*, *sexual cephaloid*) we avoid the absurdity of assigning individuality to the *egg-sac* of Hydra and others of its allies which have evidently a mere genital organ. Although we might be inclined to admit that some *cephalisms* may gradually become complete individuals, as when the buds of Actinia or Hydra separate from the parent body; on the other hand we must insist that an *individual* cannot retain the same significance when reduced to a mere *genital organ*, as when, in Coryne, a free medusoid (Sarsia) later in the season becomes an egg-sac; or the free medusa of Tubularia (Ectopleura) Dumortierii is represented in Tubularia (Thamnocnidia) spectabilis and Parypha crocea by a plain sac; or in Siphonophoræ where a subdivision may be either a sexual medusoid, or a sexless swimming-bell, or a mere "scale."

Under the term *cephalism* we include two forms, or *morphs*, viz: (1) the *cephalid*, or such subdivisions of a body as have a complete organization, whether united in common (as in some Vorticellidæ, Corals, Bryozoa, Crinoidæ, some Ascidiadæ, and Pyrosomidæ) or separating singly from the main stock (as in Hydra and Actiniæ), and (2) the *cephaloid*, or those divisions of a fissigemmating body which do not contain a complete organization, and may be either mostly *sexual* (as the so-called medusa of Hydromedusæ, or the posterior divisions of Myrianida and other worms, or the joints of Tænia, or the Cercariæ brood of Distoma, or the chain of Salpa) or mostly vegetative and *sexless* (as the hydra of Hydromedusæ, the Myrianida stock, the head of Tænia, the single, budding stock of Salpa or the budding Cercaria-nurses of Distoma.)

ART. X.—*On Laurentian Rocks in Eastern Massachusetts;* by DR. T. STERRY HUNT, F.R.S.

IN a paper read before the American Association for the Advancement of Science at Washington in April, 1854, and published in this Journal for September in the same year, (vol. xvii, page 193,) I noticed the crystalline limestones of northeastern Massachusetts, which were described by the late Dr. Hitchcock as enclosed in the great gneissic and hornblendic formation stretching through that portion of the state. These limestones, which are met with at various points from Bolton by Chelmsford on to Newburyport, present a close mineralogical resemblance to those of the Adirondacks and Laurentides, and also to those of the Highlands of New York and New Jersey, a resemblance which extends to the gneissic rocks which in these various regions accompany the crystalline limestones. I, at that time, accepted without examination the view maintained by Mather and H. D. Rogers, that these limestones in southern New York and New Jersey were altered Silurian strata, although mineralogically identical with those farther north of undoubted Laurentian age. Led by this conclusion to attach comparatively little importance to mineralogical and lithological resemblances, and guided by other considerations given in the paper just referred to, I then suggested that the crystalline limestones and their accompanying rocks in northeastern Massachusetts might probably be of Devonian age. The subsequent investigations of Hall, Logan and Cooke in the Highlands of New York and New Jersey have however left no doubt that these supposed altered Silurian rocks are really of Laurentian age, and led me to suspect that the same might be the case with those of eastern Massachusetts. This view, which was shared by Prof. James Hall, I ventured to put forward at the meeting of the American Association for the Advancement of Science at Salem in August, 1869, when I showed that it was probable, not only on lithological grounds, but from the fact that the Laurentian rocks appear to the southward of the great paleozoic basin in New Brunswick and Newfoundland, which are geologically but a northeastern prolongation of New England, and moreover from the outcropping of the lowest Silurian strata at Braintree near Boston. A few days later I visited Newburyport, and in company with Dr. Henry C. Perkins of that place, had, for the first time, an opportunity of observing the gneisses and limestones in question. Their aspect confirmed my suspicion of their Laurentian age, and led me to suggest to him the propriety of searching for *Eozoon Canadense* in the limestones which there occurs mingled with serpentine. Specimens of it were thereupon placed in the hands of Mr. Bicknell of Salem, well known as a skilled microscopist, and shortly after it was announced by Dr. Perkins that Mr. Bicknell had discovered in them the Eozoon. This notice, which appeared in September in a Newburyport journal, is reproduced in the American Naturalist for November. My own specimens collected in August last near Newburyport, at the locality known as the Devil's Den, did not however furnish any traces of Eozoon, and I may here remark that I had already, so long ago as 1864, caused slices to be made of a specimen of limestone from that locality, which were then examined by Dr. Dawson with negative results. In November, however, Mr. Bicknell visited Newburyport and got from a quarry about a quarter of a mile distant from the place just mentioned, specimens of a serpentinic limestone in which he again found Eozoon. Slices which he has kindly sent me have also been examined by Dr. Dawson, who confirms Mr. Bicknell's observation, and finds in them *Eozoon Canadense,* though fragmentary and not very well preserved. The tubuli, as in the specimens from Grenville, are injected with serpentine, and may be seen on etched surfaces as well as in transparent slices. A crystalline mineral is however abundantly disseminated in the limestone, and unskilled observers might have difficulty in recognizing the fossil.

Another locality, about twenty-eight miles to the southwestward of Newburyport, has however afforded me much better specimens. In company with Mr. L. S. Burbank of Lowell, a zealous and successful teacher of geology and mineralogy, I visited in October last, the limestone quarries of Chelmsford, some five miles from Lowell. This limestone and its accompanying gneiss closely resemble the Laurentian rocks of other regions, and scapolite, apatite and serpentine occur as associated minerals, though the latter was rare in the quarries then visited. A few days afterward Mr. Burbank kindly sent me specimens of a mixture of limestone and yellowish-green serpentine from another quarry in the vicinity, which I had been unable to visit, and these have proved to be rich in *Eozoon Canadense.* The continuous and complete calcareous skeleton of the fossil does not appear in these specimens, which seem like some portions of the rock from Grenville, as described by Sir W. E. Logan, to be made up of fragments of the calcareous shell of Eozoon, mingled with grains of serpentine, and cemented by crystalline carbonate of lime. In the specimens from Grenville, and from most other localities, the mineral matter replacing the sarcode and filling up the canals and tubuli in the calcareous Eozoon skeleton, is generally serpentine or some other silicate. Both Dawson and Carpenter however, it will be recollected, found that in the fragmentary Eozoon from Madoc, and in some small portions from Grenville, the injected mineral was like the shell itself, pure carbonate of lime, though readily distinguishable by differences in texture and transparency from the shell. Such is also the case with all the Chelmsford specimens yet examined, which abound in fragments of shell exhibiting in a very beautiful manner the cylindrical diverging and branching tubuli. The accompanying serpentine is disseminated in grains, but has no connection with the organic forms, so that, unlike the specimens in which it is the injecting mineral, the structure of these cannot be brought out by etching with acids.

These specimens from Chelmsford, it should be said, have been examined and satisfactorily identified by Dr. Dawson. The argument from mineralogical and lithological resemblances in favor of the Laurentian age of the limestone in question is therefore now supported by the undoubted presence in them of

Eozoon Canadense. In this connection it should be said that the crystalline rocks of Newburyport and Salisbury, though separated in Hitchcock's geological map from the gneisses to the southwest, and united to the syenites of Gloucester and Rockport, seem to me very unlike the latter, and closely related lithologically to the gneiss of Chelmsford, which encloses the crystalline limestone. The crystalline limestones occurring with gneissic rocks near Providence, Rhode Island, merit a careful examination for Eozoon, inasmuch as from their lithological characters they may with probability be supposed to be of Laurentian age.

Montreal, Dec. 13, 1869.

ART. XI.—*Contributions to the Chemistry of Common Salt: with particular reference to our home resources*;* by C. A. GOESSMANN, Ph.D., Professor of Chemistry, Massachusetts Agricultural College, Amherst.

HOWEVER chemists and geologists may differ in regard to the methods by .which chlorid of sodium has accumulated in the course of time within the waters of the ocean, there is at present but little dissent from the opinion, that the ocean has at all times been charged with salt, and that the saline residues of the oceanic waters of former geological periods, together with those of the present day, furnish us with our natural sources of supply.

The salt of commerce is chlorid of sodium more or less contaminated with various saline admixtures. These foreign substances may differ in *quality* or *quantity*. The differences in the kind of the foreign admixtures are due to the peculiarities of the source used for the manufacture. The differences in the *quantity* of the impurities, so far as the same kind of saline compounds is concerned, are determined not only by the condition of the source, but also by the mode of manufacture and by the amount of care bestowed upon the working. The fitness of a salt for domestic and industrial purposes depends quite frequently not less on its mechanical condition, than on its chemical purity; and as the composition of its natural as well as its artificial solutions exerts a most decided influence on both, it seems but proper that I should briefly consider the chief foreign saline compounds usually associated with the chlorid of sodium. To do this, we must go back to the primitive condition of our planet.

Accepting the theory that our earth has gradually passed

* Read before the National Academy of Science at its Northampton meeting August, 1869.

from a gaseous to a solid condition, we may assume that the formation of chlorid of sodium took place mainly during the last stages of its consolidation, at a period when the more volatile elements reacted upon each other, in consequence of the diminution of temperature; that subsequently water caused the oxydation of numerous chlorids and sulphids, the acids of sulphur and of chlorine which thence resulted acting upon the solidified surface of the new planet; and, that finally these more or less violent physical and chemical revolutions resulted in the formation of the primitive ocean.

A more prolific field for speculation concerning the kind, the extent, and the order of succession of the chemical reactions, which may have preceded or accompanied the formation of this first ocean, cannot readily be conceived, since more complicated relations of matter and force can scarcely be presented for investigation. Speculations upon the last stages of the chaos, therefore, are very likely to lead us into a chaos of chemistry; for—to point out but one circumstance—the very important question as to the relative intensity of the various chemical agencies which may have been in action at any given point, is, and will always be, a mere matter of conjecture. Inasmuch as all our knowledge concerning chemical affinity, has been obtained by experimenting, under well defined conditions and on a comparatively very limited scale, it is evident that the application even of well established chemical laws to the determination of the violent reactions of the atmospheric agencies of that period upon the solid crust of our earth, should be made with caution. We are not without ingenious statements concerning the chemistry of that stage of our planet's history; yet, as their details in many instances are and always will be subjects of controversy, I deem it advisable to give merely an outline of those probable chemical and physical changes which bear directly upon the question here under discussion.

Taking into consideration the peculiar constitution of primitive rocks, their present surface condition, and the predominance in them of silicic acid, in connection with the probable character of the primitive atmosphere, there appears to be some force in the suggestion, that the decomposition of the silicates of iron, of alumina, of lime, of magnesia, of potassa, and of soda, by means of sulphuric acid, and particularly of hydrochloric acid, may have furnished the saline constituents of this primitive ocean. The compounds resulting from this chemical action being soluble in water, at least in part, were continually carried away in solution and accumulated finally in lakes and oceans. The chemical composition of those oceanic waters was dependent, therefore, on the nature and the extent of the surface disintegration, the concentration as well as the relative proportion of their saline constituents being very different from that found at present. But on the other hand we must concede, that an entire elimination of one or more of these constituents could only be accomplished by such an alteration in the physical and chemical condition upon our planet, or in the nature of the disintegrating agencies, as would create new affinities of sufficient power, to alter the originally existing compounds. The composition of the present ocean, as compared with that of saline deposits of a more ancient date, requires the assumption of such revolutionizing causes; causes, however, which may be looked upon as merely a natural consequence of the lapse of time during the history of our earth. The same agencies in fact, which are still at work in effecting changes in the character of the saline compounds of the present ocean, suffice to explain the gradual transformation of the primitive ocean into that of the present day. The mineral acids, the presence of which we had reason to suspect in the primitive ocean, became neutralized by degrees, and ceased to react upon the newly exposed rock; and as the temperature diminished, a new disintegrating agent, carbonic acid, became active. This acid, then so abundant in the atmosphere, aided by water and oxygen, and later by vegetable and animal life, though a slower is by no means a less powerful agent in effecting the decomposition of exposed rocks; it has enriched and is still enriching the ocean with saline compounds. Carbonates and silicates of alkalies and alkaline earths were in this way introduced into the oceanic waters; and thus a gradual removal of metallic and earthy oxyds, and in some cases of those of the alkaline earths also, was effected. The sulphuric acid, exchanging the oxyds of the earths and the metals for lime, formed a less soluble sulphate, so that the amount present became dependent upon concentration and temperature. The chlorine changed from its combinations with earths and metals, only to the equally soluble compounds of the alkalies and alkaline earths. Taking the chlorid of calcium, for example, which thus far has been noticed in every salt deposit of ante-tertiary date, and which must have been therefore one of the original constituents of the ocean from which the salt originated, we find it necessary to believe that the chlorids must have always exceeded the sulphates; since an excess of any sulphate, except sulphate of lime, would have caused the decomposition of the chlorid of calcium.* An increase of the chlorids of the alkaline earths, as of calcium and magnesium, and of the alkalies, particularly of sodium, if we may judge from the present composition of the ocean, was the final result of the

* The supposition that chlorid of calcium was one of the primitive constituents, can only lose its force when some other general cause for its universal diffusion can be pointed out.

changes now indicated. The agencies which produced these changes are still at work; and hence the oceanic waters of the present day are liable to similar alteration in composition. There are reasons to suppose that for some time past one of the main changes has been the decomposition of the sulphate of lime by carbonate of magnesia, forming carbonate of lime, sulphate of soda and chlorid of magnesium. The latter compounds are characteristic of the salt deposits of recent date, as well as of the present marine waters; they could make their appearance only after the chlorid of calcium had been removed. There are of course various other means, by which this result may have been accomplished; but I prefer to confine myself to the one now given, as being of particular interest in view of the fact, that chlorid of calcium is a characteristic constituent of the ante-tertiary ocean. These changes in the oceanic waters extend apparently over long periods of time; they are more likely the result of a prolonged than of an intense action,—even from the beginning. For these reasons it must always be quite difficult to point out with anything like a certainty, the condition, and the composition of the ocean waters, during the successive stages in the geological development of our planet. All we can venture to assert upon that point may be summed up in the following statements:—*first*: the similarity of certain extensively distributed metalliferous, and other deposits within the crevices and fissures of primitive rocks, finds an apparently satisfactory explanation in the assumption, that their formation is due to a more or less localized precipitation, under circumstances similar to those we have supposed to exist in the primitive ocean; *second;* the saline compounds contained in the oceanic waters of ante-tertiary date appear to differ essentially from those of the present day; the solutions of the primitive saline deposits of distinctly ante-tertiary date containing in every instance, more or less chlorid of calcium, while the waters of our present ocean are characterized, instead, by an excess of soluble sulphates, as sulphate of magnesia and of soda for instance, which renders the existence there of chlorid of calcium impossible. We do not hesitate on the strength of these observations, to speak in general terms of a primitive ocean,—of an *ante-tertiary* or *Silurian ocean,* and of a *Post-tertiary ocean,* including in the latter that of the present day.

Whenever during the various geological epochs a larger or a smaller body of salt water was cut off from the main ocean, either in consequence of a receding of the ocean, an infiltration into natural basins, or of changes in the level of the strata, and was subsequently placed under favorable climatic conditions for its evaporation and the subsequent preservation either in whole or in part of its saline residue, then a salt deposit was produced. Such saline residues, commonly known as *rock salt*, have been found in almost every geological horizon, from the Silurian upward, and in many localities they are still forming at the present time. Sometimes several independent deposits occur one above the other, interstratified with the rocks of the same geological basin.

Most of the foreign salts which accompanied the chlorid of sodium in the marine waters, being more soluble than the chlorid of sodium itself, accumulated during the evaporation in the residual liquid, commonly known as mother-liquor, which covered, at least in part, the separated crystalline mass of chlorid of sodium and sulphate of lime. The amount of these salts and the manner in which they overlie the solid saline mass, is dependent on the form and the shape of the basin in which the deposits accumulated. As these mother-liquors uniformly contained a large number of deliquescent compounds, we must assume very favorable climatic and meteorological conditions to account for their evaporation, since the rate at which this took place, must have exceeded by far that of the precipitation of moisture. Whether such a state of the atmosphere was the general rule in former ages, is of course quite uncertain. Moreover, although actual investigations have demonstrated the entire absence not unfrequently of the upper layers of such saline deposits, this fact cannot be admitted as an argument against the assumption of a common marine origin of all salt deposits. For, even granting that in former geological ages, the extraordinary state of the atmosphere did exist, which would be required to effect the solidification of the entire saline mass—mother-liquor and all—there remain numerous subsequent influences, by which a part or the whole of the saline residue of the original mother-liquors, even after their complete solidification, could have been removed from a saline deposit. In fact, considering the many casualties to which these saline accumulations are liable in the course of time, it would be strange indeed, if many entire and well preserved marine salt deposits should be found.

We may assume then with some propriety, in cases where salt deposits are found without their associated foreign saline compounds, that these have been lost, either by oozing out, never having been solidified, or after solidification, have been removed by the percolation of surface waters, by subterranean currents, by peculiar secondary chemical and physical reactions or by erosive action on the surface layers. In all probability quite as many deposits have been modified in their physical and chemical characters by the subsequent elevation of their enclosing strata, a circumstance which must have favored the percolation of surface moisture, as have been changed by denudation.* Indeed these changes have sometimes gone so far as to leave nothing but the layers of gypsum which are the substratum of all well investigated rock-salt deposits.

As the circumstances necessary for the preservation of entire salt deposits, or saline marine residues can scarcely have been the same, even throughout the same geological age, it is not surprising, that these deposits so frequently differ in their physical and chemical characters. In fact there is at present but one salt deposit known, and its discovery is of quite recent date (Stassfurth), where the entire saline mass of the ocean has been preserved; in this deposit the various saline compounds are to a large extent arranged in layers, which correspond closely with the degree of their solubility; yet even in this one instance there are facts noticeable, which leave no doubt that portions of the deposit have been exposed to peculiar disturbing influences at a later date.

But not only may salt deposits be placed under conditions which permit their re-solution, there may be in addition a re-evaporation of this solution, producing a secondary salt deposit. This requires only a repetition of the circumstances, which favored the formation and preservation of the original one. A primary salt deposit may be dissolved entirely or only in part; in either case the solution may or may not be changed in composition by filtering through the adjacent beds. Both primary and secondary salt deposits may occur in the same geological (*Post-Silurian*) formation. Secondary reactions of a physical as well as a chemical nature too may alter the character of the surrounding geological formations, and thus may indirectly affect the composition of a salt deposit, as is the case for instance at Stassfurth. The conditions which have now been given may suffice to explain to us the great variations we notice in the chemical composition both of rock salt and of brines; they may also serve as a suitable illustration of the great risk we incur, when we assume to draw conclusions of an absolute character from the geological formation in which the salt deposit has been found, as to the chemical composition of the oceanic waters of that geological age.

With these preliminary remarks upon the origin of chlorid of sodium and its associated salts, I pass on to consider the main sources of supply of common salt, with particular regard to those of this country.

The leading sources of supply for the manufacture of salt, as already stated, are three in number, *Rock salt*, *Brines*, and *Sea-water*. A. *Rock salt:* From what has been said it is manifest that rock salt from different localities may differ widely, both in

* As the rock salt deposit of Petit Anse, Louisiana, for example, and most likely that which furnishes the brines of Onondaga.

physical and chemical properties. Usually it occurs either in densely aggregated masses of distinctly cubical crystals, or in compact masses having a conchoidal fracture; it is frequently colorless and transparent, yet is more often either red, yellow, or blue, rarely green. Its most frequent saline admixtures are 1st, sulphate of lime, the chlorids of calcium, magnesium, and potassium, and the bromid and iodid of magnesium; or 2d, the sulphates of lime, magnesia, and soda, the chlorid, bromid, and iodid of magnesium, etc. A rock salt, which contains more than from 2 to 3 per cent of these impurities is unfit for domestic uses; and a salt which contains carbonate, nitrate or borate of soda, or similar foreign substances is, especially in its natural state, frequently unfit even for many manufacturing purposes also.

Rock salt deposits are frequently intercalated with layers of gypsum and clay, a fact due to the successive periods of evaporation; such conditions require especial care in mining the salt. Colorless and dry rock salt deposits having a fair composition and easy of access are mined directly with advantage; the salt obtained thereby, after being brought into a desirable form, is directly applicable to most domestic purposes, particularly meat packing. Colored salt deposits, or those which suffer from percolating waters, or which contain a large amount of foreign saline admixture, or clay; or finally, those which are located at very great depths, if worked at all, are usually dissolved, and their solutions treated like brines.

The northern part of this continent contains numerous salt deposits; some quite recently discovered, like that upon Petit Anse Island, Vermilion Bay, Louisiana, the one in Canada West, at Goderich on the shores of Lake Huron, and also that of Neyba, St. Domingo, West Indies, being of particular interest. Newspaper reports too tell of mountains of rock salt in Arizona and Nevada. The salt deposit at Goderich is buried in the shales of the upper Silurian (T. S. Hunt), at a depth of from eight to nine hundred feet; it is about forty feet thick, covers so far as present indications show, dozens of square miles, and is in close proximity to Lake Huron; its solution furnishes the superior brines at Goderich.* The salt deposit of Petit Anse, Louisiana, is apparently imbedded in Quaternary formations (E. W. Hilgard), and is covered merely by a diluvial drift from 16 to 18 feet in thickness; its extent is unknown, having been but partially explored. It is accessible by sea and by land, and is within 275 miles of the mouth of the Mississippi river. This Petit Anse rock salt, so far as at present exposed, is one of the

* Report on the Salt Resources of Goderich, Canada West, by Chas. A. Goessmann; Syracuse, N. Y., January, 1868.

purest on record.* At the present time there is but little rock salt, as such, used in the United States. Natural solutions of rock salt furnish us with the brines of Saltville in North Western Virginia, of Goderich, Canada West, and, as I believe, of Onondaga, N. Y.

B. *Brines.*—Brines are either natural or artificial; that is, they are either natural solutions of saline deposits, or they are made artificially by dissolving rock salt. In regard to natural brines we are quite frequently ignorant of the exact location, the extent and the nature of the saline mass from which they originate, while in the case of artificial brines, we are familiar at least to some extent, with the nature of the sources from which our supply is drawn.

Brines differ in strength and in composition, scarcely two of them being alike. In strength they vary from three to twenty-six per cent of saline matter, though weak brines are frequently strengthened for manufacturing purposes by adding rock salt. Their composition depends on the peculiar nature of the original source, and on the secondary influences to which they are exposed in passing to the surface; an intercepting stratum often modifying materially their original composition.† Moreover brines from the same salt deposit frequently differ widely in composition; the upper parts of the deposit containing as a general rule, more of the foreign salts than the lower portion; the exceptions being accounted for by extensive surface erosions and percolating waters.‡ Again, the upper layers of salt deposits being more exposed to surface action, as for instance, to infiltrations, which may cause chemical changes, are thus particularly liable to suffer from the accumulation of foreign admixtures, derived from the disintegration of the overlying rocks. Brines originating from the surface layers of a salt deposit are therefore usually inferior in composition to those coming from its lower portion.

The impurities of brines are those which are found in rock salt, but in many instances they contain also the carbonates of lime, magnesia, and protoxyd of iron, carbonic acid, and hydrosulphuric acid, besides organic matters. These last named have found access to the brine in most cases during its passage to the surface.

Brines are divided§ according to the character of the saline admixture, into two classes; those of the *first class* contain the

* See my statement in a report of the American Bureau of Mines. On the rock salt deposit of Petit Anse, etc., New York, 1867; and also Dr. E. W. Hilgard's statements in Proceedings of American Assoc. for the Advancement of Science, Aug., 1868.

† See my contribution to the Chemistry of Mineral waters, etc. Syracuse, N. Y., Feb., 1866, also this Jour., 1866.

‡ See my contribution to the Chemistry of Brines, this Jour., July, 1867.

§ Ibid., p. 80.

chlorids of calcium and magnesium, and sulphate of lime; those of the *second class* contain no chlorid of calcium, but only chlorid of magnesium, with the sulphates of lime, soda and magnesia; the first class are supposed to originate chiefly from the saline residue of the oceanic waters of ante-tertiary date, while the second class represent most probably derivatives of the former. All the brines found east of the Mississippi river belong, so far as my own information extends, to the first class, as they contain chlorid of calcium. The second class of brines is largely represented west of that river; for instance in Nebraska, Kansas, and Arkansas.

I. 1*st Class of brines and salt.**

	Brine of Goderich C. W.	Brine of Onondaga, N. Y.	Brine of Mich. (Saginaw Valley.)		Salt of Ohio, (Hocking valley.)		Brine of Kentucky.	Brine of Tenn.
			I.	II.	I.	II.		
Sulphate of lime,	0·5433	0·5747	0·0755	0·4887	0·0881	0·1060	traces	0·2978
Chlorid of calcium,	0·0216	0·1533	2·9422	0·4020	1·1360	0·6140	0·7009	1·1793
Chl'd of magnes'm,	0·0336	0·1440	1·2616	0·3710	0·4744	0·0409	0·7312	0·9587
" of sodium, etc.	24·1433	15·5317	19·8595	12·5315	92·8	95·7	6·7684	9·8952
Water,	74·8	83·	76	86·0	5·9	3·4	91·	87·

II. 2*d Class of brines and salt*; it includes all kinds of salt made from oceanic waters.*

	Nebraska (brine).	Nebraska (salt).	Kansas (salt).
Sulphate of lime,	0·1256	0·2475	1·1222
Sulphate of soda,	0·5808	0·3912	0·3511
" " magnesia,	----	----	0·1794
Chlorid of magnesium,	0·1542	0·0790	0·2400
Chlorid of sodium, etc.,	0·3150	98·12	93·06
Water,	90·	0·8	4·8

The value of a brine for manufacturing purposes does not depend entirely either upon its density or upon the relative percentage of chlorid of sodium and of foreign saline admixtures; the *kind* of the impurity is of the greatest importance; for instance, the sulphate of lime and even the sulphate of soda are considered far less objectionable, within proper limits, than a corresponding amount of the deliquescent chlorids of calcium and magnesium.

Saline springs are scattered all over the United States, their number having been largely increased by the recent extensive explorations for oil; the amount of brine which they can yield is apparently inexhaustible. Foremost among them are the brines of New York, (Onondaga co.), southeastern Ohio, western Virginia, Michigan, Pennsylvania, and of late Nebraska and Kansas. The brines of New York, Ohio, Virginia, Pennsylvania, Michigan, Tennessee, Kentucky, and Canada West, resemble each

* These analytical statements by no means express the commercial value and the relative purity of the salts and brines, they claim merely to indicate their peculiar character.

other closely. They all belong to the first class of brines, and all contain chlorid of calcium; they differ merely in the relative proportion of the impurities which they contain. The brines of Lincoln co., Nebraska, and of Smoky Hill river valley, Kansas, etc., contain chlorid of magnesium, and the sulphates of lime and soda, but no chlorid of calcium. They represent the second class of brines. Most of the saline waters of this country are, even in their natural state, strong enough to be worked directly by artificial heat. All our home manufactured salt, coarse as well as fine, with the exception of a small quantity obtained from sea-water, has thus far been made from natural brines; fully one half of the whole amount for a number of years having been obtained from the brines of Onondaga, New York State.

C. *Sea-water.*—The water of the ocean is a weak brine; it contains from three and one half to four per cent of saline matter, of which three fourths is chlorid of sodium and one fourth is impurities; it is free from chlorid of calcium, and belongs properly to the second class of natural brines. Its impurities consist mainly of chlorid of magnesium, the sulphates of lime, magnesia and soda, besides smaller quantities of chlorid of potassium, bromid and iodid of magnesium, and carbonate of lime, with traces of oxyd of iron, etc. Sea-water varies but little in composition and concentration, except in localities where either a limited body of water is prevented from unrestricted communication with the ocean, or where a large influx of fresh water causes its dilution. It represents the main source of supply for the manufacture of salt in France, Portugal, Spain, Italy, the West Indies, and Central and South America; it is used also largely for the production of salt in England, Belgium and Holland, being frequently employed for the solution of rock salt of inferior color. In the United States it has been turned to advantage but to a very limited extent. Three hundred to three hundred and fifty thousand bushels cover, in all probability, our present production of salt from sea-water. The States of Massachusetts, North Carolina and Florida on the Atlantic, and of California on the Pacific Ocean, have mainly been interested in this branch of industry. The late increase in the production in Florida, and on the Pacific coast, more than compensates for the falling off elsewhere.

In concluding this paper it may be well to re-state the fact, that the comparative commercial value of various samples of salt, so far as their composition is concerned, does not always depend upon the relative proportion of chlorid of sodium to foreign admixture. A mere analytical statement giving the percentage of impurity, without specifying its kind and nature, gives no reliable standard by which to pronounce upon their commercial value, since the various impurities, which the salt has retained, are objectionable in quite different degrees; thus a sample which contains from one to one and a half per cent of foreign salts, consisting almost exclusively of sulphate of lime, may claim to be a very fair article of common salt; whilst if it contains but one half of that amount of the chlorids of calcium and magnesium or of the sulphates of soda and magnesia, together with the chlorid of magnesium, or of the carbonates of lime and magnesia, it would be considered quite objectionable, at least for table and dairy purposes. Again, the superior fitness of a sample of salt for many domestic purposes, does not depend entirely on its chemical composition; its mechanical condition is quite frequently of not less importance. A well devised mode of manufacture, ought therefore, not only to aim at the most perfect removal of foreign impurities, it must also secure to the salt the best mechanical condition. The manufacturer in selecting a mode of working is consequently limited in his choice; he must often sacrifice purity to mechanical condition, being obliged to adopt a method which promises to secure most economically a desirable article from his brine in the purest condition possible. So far as the form is concerned there are two kinds of salt in commerce; (a), *coarse salt* including salt made by solar heat, and rock salt crushed to a suitable size; and (b), *common fine salt*, or boiled salt obtained by artificial heat and more rapid evaporation; both kinds have their special market value. The amount of salt consumed for the promotion of animal life far exceeds that required by vegetables, but the amount demanded for meat packing and for the dairy business is very much larger. In the industrial arts, we can scarcely claim that any of our home resources have been turned to account. A proper exposition of the various uses to which salt is applied in chemical manufacturing industry would be a description of one of the most important chemical arts of the present day. To do justice to this question would require more time than I feel entitled to claim. I shall therefore confine myself merely to the presentation of a few statistics in regard to the quantity annually produced.

England produces from thirty to thirty-two millions of bushels of salt, (56 lbs. each), of which seventeen millions are used for the manufacture of soda ash, sal soda, caustic soda, bicarbonate of soda, hydrochloric acid, bleaching powder, etc., etc., while about two-thirds of the rest is exported, leaving scarcely one-fifth of its whole production for domestic consumption.* The production of salt in the United States amounts at

* England abolished its tax on salt in 1823. The price has varied only within narrow limits for many years past; the production in some localities has changed much since that time; for instance, Worcestershire produced in 1823 but 9,000

present to from sixteen to eighteen millions of bushels, and the consumption to from thirty-two to thirty-four millions of bushels; in other words, almost one bushel to every head of its population. This large consumption of salt is due to our extensive meat packing and dairy business; the consumption for manufacturing purposes being scarcely worth mentioning. Almost one-half of the amount of our present consumption, it will be noticed, is imported. We must consequently increase our production to twice the present amount, if we would supply our present demand; and if we would support the industrial arts at the rate England does, we must increase this production more than three times. Our natural sources of supply would, even in their present incomplete state of development, suffice to furnish the amount required. Our prospects might therefore be considered highly gratifying, if the question of quantity only were involved. But as the cheapness of the raw material and of labor are not less important points, which ought to be duly weighed before entering upon a new industrial enterprise in which skill and capital have for years secured a monopoly in the market, we must acknowledge that we are not yet fully prepared to enter the lists as successful competitors. Some of our older salines are not yet sufficiently explored to warrant the expectation of a cheap supply from them in their present condition, and many of our recently discovered brines are too far from cheap communication or from centers of skill and industry, to be to any extent available for our present emergencies.

In some of the countries in Europe, where the government holds the salt monopoly for revenue purposes, the practice has for obvious reasons been adopted of taxing the salt used for domestic purposes, while the salt used for manufacturing purposes is supplied at cost, being first rendered unfit for domestic application by the addition of ground charcoal, oxyd of iron, etc. These additions are selected with reference to the particular use for which the salt is intended. May intelligently directed individual enterprise, supported by a wise legislation, soon recognize the proper means by which our home production may be best stimulated, and thus our chemical industry receive the most important element for its successful and rapid development.

tons, while its present production is 200,000 tons; the Cheshire salt works are capable of making one million of tons per year; in both cases the sources of supply exceed the demand. The Worcestershire works export annually 50.000 tons, while the Cheshire works export 650,000 tons. The Stoke's works employ 500 hands, produce about 3,000 tons per week, consuming 1,500 to 2,000 tons of coal. A fair workman at 2s. per ton will make 28s. per week.—(*Chem. News,* No. 377, Feb., 1867, page 88.

Amherst, Mass., August, 1869.

ART. XII.—*Account of a fall of Meteoric Stones near Danville, Ala., with an analysis of the same ;* by J. LAWRENCE SMITH, Louisville, Ky.

ALTHOUGH the meteorite of Danville, Alabama, fell in Nov., 1868, and an analysis has been made of it during the past summer, it is only recently that I obtained a complete account of the phenomena attending its fall.

On Friday evening, Nov. 27th, 1868, about five o'clock, Mr. T. F. Freeman, of Danville, (about lat. 34° 30′ and long. 87° W. Greenwich), on stepping from his house, was startled by a loud report, so much like artillery that for the moment its origin was attributed to the firing of a small piece of artillery kept in the village, but on inquiry it was ascertained that no firing had taken place there, but that the sound was heard at the village, and attributed to very heavy artillery at Decatur, Trinity, Hillsboro, or some other point to the northward of Danville. During the war, artillery had been often heard in the valley of the Tennessee, and various speculations were indulged in as to what was meant by this cannonade at such a time of day and in such a direction.

The following day, Mr. Wm. Brown, living three miles west of Danville, brought to the village a piece of rock which he said fell near him and some laborers, who were picking cotton. He dug it up at a depth of about 1½ to 2 feet. It weighed about 4½ lbs., and had the characteristic aspects of a meteoric stone; but it was broken by the party obtaining it, and all but about half a pound, now in my possession, has been scattered and probably lost or thrown away.

Several other stones fell in the same vicinity. Some negroes working in a cotton field on the plantation of Capt. McDaniel, half a mile from Danville, heard a body fall with a whizzing, humming sound, and strike the ground near them with tremendous force ; but they were alarmed and did not approach the spot that night ; a rain fell during the night and no trace of it could be found the next day. Various other stones were heard to fall in different parts of the adjacent country. Two brothers, by the name of Wallace, were ploughing in their field, about 1¾ miles N. W. of Danville ; they distinctly heard two or three fainter reports, after the first loud one, and heard the sound of two falling bodies whizzing down, one to the right and the other to the left of them.

With the above data, and the known geography of the country, its direction must have been N. E. and S. W., but it is impossible to say from which of these quarters it came.

The portion of the meteorite that I possess has a large portion of it covered with the usual black crust. Its general aspect is rough and dull; a portion of the outer surface, not covered with the black coating, is nevertheless a surface that it had when it reached the ground, for on this surface are streaks and little patches of a bright, pitchy matter, which was once fused, and was derived either from another part of the coating that was thrown off in a melted state from the coated portion, and whipped around, (as it were), on to the unfused surface as the stone fell through the air, or from an incipient fusion that was begun on the denuded surface, and arrested by the termination of the fall. Where the black crust reaches the denuded places, it appears to be rounded off, as if it had been melted matter passing from another portion of the stone, and rolled over the surface of the borders.

The broken surface has a dark gray color, and is somewhat oolitic in structure, but not as much so as many other meteoric stones. There are veins and patches of a slate-colored mineral running through it. Pyrites and iron are also to be seen diffused through the stone; thin flakes of the iron giving that slickenside-like appearance to a fracture not unfrequently seen in this class of bodies. There seems to be more of iron in the slate-colored mineral than in the other parts. There are a few patches of white mineral, which I take to be enstatite. The specific gravity of the stone is 3·398.

For further examination, a portion of the meteorite was separated mechanically into three parts; the pyrites, the metallic iron, and the earthy minerals. As in the case of most meteorites, the earthy minerals were so intermixed that it was impossible to separate the different varieties, three of which were easily traceable by the eye.

The iron separated with great care from the pulverized meteorite constitutes 3·092 per cent of the entire mass, and an analysis furnished

Iron,	89·513
Nickel,	9·050
Cobalt,	0·521
Copper,	minute quantity
Phosphorus,	0·019
Sulphur,	0·105
	99·208

The sulphid of iron detached very carefully from the mass of the meteorite gave

Iron,	61·11
Sulphur,	39·56
	100·67

which corresponds with the protosulphid of iron, FeS. Whether it contains any of the sulphid known as troilite I am not prepared to say.

The stony minerals were freed as much as possible from iron and pyrites, and one gram treated with ten grams of hydrochloric acid on a water bath, and evaporated nearly to dryness, then filtered and the filtrate well washed; after which, the residue in the filter was warmed with a solution of caustic soda to dissolve any silica belonging to the portion dissolved by the acid; it was then filtered again and washed. The result was

Soluble portion,	60·88
Insoluble portion,	39·12

The treatment by a solution of caustic soda or potash is of importance for a correct result, as otherwise a portion of the silica of the decomposed minerals will be estimated with the portion that is undecomposed.

The insoluble portion was analyzed; for although the analysis made in this way cannot furnish any positive indication in regard to the true mineral constitution of the meteorite, it is, nevertheless, an important guide. It was found to consist of

Silica,	50·08
Alumina,	4·11
Protoxyd of iron,	19·85
Magnesia,	20·14
Lime,	3·90
	98·08

From all the circumstances connected with this mineral, its physical characters, &c., it is doubtless a pyroxene of the augite variety.

The soluble portion, owing to the unavoidable presence of a little iron and pyrites, simply furnished results on analysis that showed it to be mostly olivine. The only matter, as a whole, freed as much as possible from pyrites and nickeliferous iron, gave

Silica,	45·90
Protoxyd of iron,	23·64
Magnesia,	26·52
Alumina,	1·73
Lime,	2·31
Soda,	·51
Potash,	·64
Oxyd of manganese, a minute quantity, not estimated.	
Oxyd of Chrome, " " " "	
Phosphorus, " " " "	
Lithia—marked reaction with the spectroscope.	
Sulphur,	1·01

The excess in the footing up of the analyses above 100 per cent is due to the fact that a part of the iron, estimated as protoxyd, is combined with sulphur forming sulphid of iron.

This meteoric stone is similar in every respect to that which fell March 28th, 1859, in Harrison county, Indiana, (which locality I see referred to, in catalogues of meteorites, as Harrison county, Kentucky). This meteorite is therefore composed of

Nickeliferous Iron,....................
Olivine,.............................
Pyroxene,...........................
Protosulphid of iron,...................

with minute quantities of schreibersite, chrome iron, and probably albite.

In concluding these observations on the Danville meteorite, I cannot but feel more and more convinced of the importance of a thorough reëxamination of the mineral nature of the meteoric stones, and in the present case, I am not at all satisfied that the mineral characteristics are perfectly made out.

ART. XIII.—*Contributions to Zoölogy from the Museum of Yale College.* No. V.—*Descriptions of Echinoderms and Corals from the Gulf of California;* by A. E. VERRILL.

THE Museum has recently received a large and important collection of Radiata, collected by Capt. J. Pedersen in the vicinity of La Paz. The following notes and descriptions relate to some of the more interesting species only.

ECHINOIDEA.

Meoma nigra Verrill.

Meoma nigra Verrill, Trans. Connecticut Acad., i, p. 317, 1867.
Kleinia nigra A. Agassiz, Bulletin Mus. Comp. Zoöl., p. 27. 1863.

Of this interesting species there are ten specimens in the collection, which show considerable variation from the type formerly described by me, as well as among themselves.

The largest is 4·85 inches long, 4·25 broad, 2·10 high; the smallest 3·85 long, 3·40 broad, 1·75 high. The outline, as seen from below, varies but little and is broad-oval, somewhat emarginate anteriorly, obliquely truncate posteriorly, and slightly compressed laterally, or, in other words, nearly heart-shaped. The anal area is large, somewhat sunken, and is at the extreme posterior end of the shell, occupying the greater part of the truncated portion. Its form varies from regularly elliptical, acute at each end, to broad-oval, rounded below and acute above; its position varies from nearly vertical to decidedly oblique, and it is so nearly terminal as to produce a posterior emargination in a dorsal view of the shell. In a side view some specimens are decidedly depressed, but most are regularly arched, while one is decidedly elevated at the apex. There is considerable variation in the depth of the anterior ambulacral groove, and also in the number and prominence of the large tubercles, which are more or less restricted to the region enclosed by the peripetalous fasciole. The fasciole itself shows remarkable variations, but does not agree at all with that of *M. grandis*, as figured by Gray. The portion crossing the anterior interambulacral regions varies less than other parts, but in some the intermediate transverse portion is nearly straight, in others strongly curved and often crooked, in one it is bent up into a right angle on each side of the ambulacral groove; its bend or angle near the antero-lateral grooves is also variable, both in form and extent, it being twice as large in some specimens as in others, and in one an irregular, crooked branch passes from the apex of the angle on the left side to the anterior groove. In the posterior interambulacrum the course of the fasciole is quite variable, in five examples it crosses with a strongly curved upward bend, without any distinct angle, rising highest in four specimens on the right side, in the other forming a nearly straight transverse middle portion; in three specimens it forms a sharp angle on the right side; in one a similar angle on the left side; in another there is a strong median angle, its apex pointing to the anal region, and another to the right of it, pointing to the summit; in all the specimens it bends inward further than in *M. grandis*. The lateral part of the fasciole also varies, especially on the left side; in five (but not the same five that agree in the posterior region) it has but one angle, near the antero-lateral grooves, where it rises highest; in three it has two angles, rising highest at the posterior one, and nearly straight between; in two others, which also have two angles, the transverse part is double. On the other side the fasciole varies in the same way, but not in the same specimens, for some have two angles, both on the right and left; others two only on one side; others one on both sides. The anal fasciole is also variable; usually the subanal branch is wanting or indistinct, though indicated by a band of smaller tubercles, but in one specimen it is well marked and the subanal disk is clearly and perfectly circumscribed. In this the subanal disk is very broad, bilobed, narrowest in the middle, scarcely heart-shaped, the anterior border being nearly transverse, and the posterior border nearly parallel with the anal region and about ·15 of an inch from it. In others the posterior border is more curved. One specimen has but three ovarial openings, the rest four. The proportionate length of the ambulacral grooves varies considerably, both in different specimens and on opposite sides of the same individual, sometimes those on the right being longest, sometimes those on the left, and not uncommonly a longer anterior one is offset by a shorter posterior one on the same side.

Mr. A. Agassiz thinks this species may be identical with *M. grandis* Gray, described as from Australia, but if the figure of the last be at all correct my specimens differ widely from that described by Gray. The position of the anal area, especially, is quite different, it being in Gray's figure at a considerable distance from the posterior end, and therefore more ventral and nearer the subanal fasciole. The peripetalous fasciole is also very different from that of any of my specimens.

Agassizia subrotunda Gray.

Catalogue Ech. of British Mus., p. 63, tab. 3, fig. 2; Verrill, Proc. Bost. Soc., vol. xii, p. 381.

A. ovulum Lutken, Vidensk. Medd., p. 134, tab. 2, fig. 8; Verrill, Trans. Conn. Acad., vol. i, p. 320.

Of this species there were about a dozen specimens, mostly more or less broken, which show but little variation and agree well with Gray's figure.

Mr. A. Agassiz regards this and *A. ovulum* Lutk. as identical with *A. scrobiculata* Val., which may well be the case if the figures in the Voyage de la Vénus be incorrect, as he states. The figures are certainly very unlike our specimens.

Clypeaster speciosus Verrill, sp. nov.

Depressed, gradually rising toward the apex; the lower side sometimes slightly concave from near the edge of the mouth, in other specimens flat except close to the mouth, which is much sunken. Outline oblong-pentagonal, with rounded angles and slightly concave sides. The anterior end slightly elongated. Interambulacral regions decidedly concave between the ends of the ambulacral rosette; the ambulacral regions enclosed by the pores slightly raised, narrow, elongated, widening but little outwardly and somewhat acuminate at the end, which is often nearly enclosed by the pores. The interambulacra are broader and decrease much more rapidly toward the apex than in *C. rosaceus.* Anal opening tranvsersely oval, or rounded, situated about its own diameter from the edge of the shell.

Length of largest specimens 4·60 inches; breadth 3·90; height 1·15. Length of anterior petal, from the apex 1·90, its breadth ·82, breadth of enclosed space ·50; length of anterior petals 1·70, breadth ·85, breadth of enclosed space ·48; length of posterior petals 1·80 and 1·85, breadth ·94, of enclosed space ·58 and ·60; diameter of anal opening ·20; of actinal opening ·33.

Thirty-five specimens of this species are contained in the collection. They show but little variation in outline, except what is due to age, though some specimens are more elevated toward the apex than others; in regard to the flatness or concavity of the lower side there is, however, great variation, though Dr. Gray used this character in dividing the genus into sections. The youngest specimens are 2·30 long by 2·10 wide, and are more oval in form and scarcely angular, but have the flatness and form of ambulacral rosette characteristic of the larger specimens, as well as the same position of the anal opening.

From *C. rosaceus* of the Atlantic this species differs widely, the former having a much more elevated and thick form, with broader and more obovate ambulacra, which are much more swollen; the lower side is much more concave, and the anal opening nearer the edge.

Some of the species described by Dr. Gray from the Indo-Pacific faunæ (*C. Australasia*, *C. testudinarius*) seem to be more closely allied, but only a direct comparison of specimens can settle the true relations of these species. It may be that *C. testudinarius* is the same and its locality incorrect, its outline being nearly identical, but the upper side is said to be evenly convex, and the lower side concave from the margin.

This species is of especial interest as the first of the genus known from the Pacific coast of America, although the genus was known to occur on nearly all other tropical coasts.

Encope grandis Agassiz.

Of this very distinct species there are numerous specimens in the collection, varying in size from 3 inches in length by 3·20 wide, to 4·60 inches by 4·40. There is but little variation in outline and general appearance, and in all the margin is thick, with the five large notches widely open, though in the larger there appears to be a tendency to close the anterior pair. The posterior interambulacral opening is large and broad-oval with thickened borders in all, but there is a variation of more than 50 per cent in its relative size; the region around it is in all more elevated than the central region and considerably swollen. The form of the ambulacral rosette varies considerably. The three anterior petals are subequal and usually long-oval, obtusely rounded at the end, but in one case they are narrower and more elliptical, especially the odd anterior one, which is widest in the middle, tapering to each end, and in another they are broader and more dilated outwardly than usual; the two posterior ones are much longer, widest outwardly, and curve somewhat around the posterior opening, but they vary considerably in relative width. The following are the proportions in two extreme specimens:

From abactinal center to posterior edge,	2·20	2·20
Center to anterior edge,	1·98	2·00
Center to lateral edge,	2·20	2·10
Length of anterior odd ambulacral petal, from center,	1·28	1·25
Greatest breadth of do.,	·50	·68
Breadth of its enclosed area,	·20	·30
Length of antero-lateral pair,	1·25	1·15
Breadth of do.,	·50	·65
Breadth of enclosed area,	·16	·27
Length of posterior pair,	1·65	1·55
Breadth of do.,	·45	·62
Breadth of enclosed area,	·12	·20

The branchings of the ambulacral grooves beneath are quite constant in their arrangement, but the relative breadth and form of the enclosed areas are quite as variable as in the dorsal rosette. The region about the anal opening and around the posterior foramen is sometimes deeply concave or excavated; in most cases slightly so; and sometimes not at all.

Encope Californica Verrill, sp. nov.

Test broad, thin at the edge, rounded anteriorly, broadest behind the middle, sub-truncate or rounded posteriorly; usually about as broad as long, sometimes broader than long. Apex behind the center. In profile the outline descends from the center to the anterior edge, but rises from the center to the posterior foramen, from which it descends rapidly to the edge. The posterior interambulacrum is, therefore, swollen and the test is most elevated near its foramen. Ambulacral rosette with the petals long-oval, somewhat obovate, broadly rounded outwardly; the anterior pair shortest and most rounded; the odd anterior one somewhat longer and narrower and a little shorter than those of the posterior pair, which are of about the same form and not curved. Posterior foramen variable in form and size, usually rather small, regularly oval, or rounded, sometimes long oval, or even narrow and elongated, occasionally quite large and broad oval, often obovate beneath, sometimes constricted in the middle. Ambulacral foramina also quite variable in form and size, but commonly small and rather regularly oval, often at a considerable distance from the margin.

Two specimens, showing the extreme variations, give the following measurements:

Length of test,	4·75	4·30
Breadth,	4·65	4·30
Center to anterior edge,	2·45	2·15
" " anterior foramen,	1·80	1·65
" " lateral edge,	2·35	2·15
" " " foramen,	1·60	1·50
" " posterior edge,	2·45	2·25
" " postero-lateral foramen,	1·85	1·70
" " posterior foramen,	1·15	1·10
Length of " "	·67	·60

Breadth of posterior foramen,	·22	·26
Length of anterior ambulacral petal, from center,	1·42	1·32
Breadth where widest,	·65	·50
Breadth of enclosed area,	·30	·18
Length of antero-lateral petals,	1·28	1·10
Breadth,	·67	·50
Breadth of enclosed area,	·28	·20
Length of postero-lateral petals,	1·58	1·35
Breadth,	·68	·53
Breadth of enclosed area,	·25	·16

Of this species there are 74 specimens in the collection from La Paz, and I have seen others from Cape St. Lucas. It varies considerably in outline, and in the form of the openings, especially the posterior one; the ambulacral rosette varies somewhat in the form of the petals, as shown by the above measurements; the ambulacral grooves beneath also vary in direction. But all the specimens agree in having their greatest elevation behind the center, or the posterior interambulacral region swollen. This peculiarity, which is found to depend upon a very different internal structure, will readily separate this species from *E. occidentalis* V., and from *E. micropora* Ag., whether those be the same, as Mr. A. Agassiz supposes, or not.* In *E. occidentalis* the greatest elevation is in front of the center, and there is a regular slope from thence to the broad, thin, posterior edge, and the sections show that the wide space between the central cavity and the posterior foramen is filled with a pretty firm, alveolary tissue having comparatively small spaces, but in *E. Californica* the same region is much less extensive (owing to the relatively larger central cavity and jaws) and is filled with a much less firm and more open tissue, with large cavities.

The difference is therefore analogous, in respect to external form at least, to that which separates *E. Michelini* from *E. emar-*

* Mr. A. Agassiz, in the Bulletin of the Museum of Comp. Zoölogy, No. 9, p. 266, 1869, says: "from a careful comparison of specimens of *E. cyclopora, micropora,* and *perspectiva* (Ag. species) there is no doubt that these are only nominal species, all identical with Verrill's *E. occidentalis.*" The latter is the same as *E. tetrapora* Ag. (non Gmelin), but I believe Mr. Agassiz goes too far in uniting all these other forms into one species, for if this can be done there is no reason whatever for keeping the species from the two coasts separate, for there is often much less difference than between some of those forms, which he has united. But since the localities of the types of *E. micropora*, *E. cyclopora*, and *E. perspectiva* were unknown, the two last having been described from unique specimens, it seems to me more probable that some of them represent imperfectly known species from other regions; for such species have been recorded from Africa and other little explored localities. Mr. Agassiz does not state what he regards as the characteristic of the polymorphous species thus constituted, nor in what respect it differs from *E. emarginata* of the Atlantic, nor does it appear certain that he has examined authentic specimens of all these forms. Dr. Lutken referred both *E. micropora* and *E. grandis* to the Atlantic *E. emarginata*, to which he also united *E. Valenciennesii* Ag., *subclausa* Ag., *oblonga* Ag., *quinqueloba* Esch., and *E. Michelini* Ag. In regard to *E. grandis* and *E. Michelini* he appears to have erred, but the figures of *E. micropora* resemble some forms of *E. emarginata* more than *E. occidentalis*, from which *E. cyclopora* and *E. perspectiva* differ still more widely.

ginata,—a distinction which Mr. A. Agassiz admits as valid in that case, where there is, however, much less difference in the form of the rosette and other characters.

The only figure in the monograph by Prof. Agassiz, which approaches this species, is that of *E. emarginata* (Tab. 10), which has, to some extent, the same posterior elevation. The specimen figured was from an unknown locality, and may possibly represent a variety of this species rather than of the *E. emarginata* of Lutken, A. Agassiz, etc., which is common on the Atlantic side of tropical America.

Astropyga venusta Verrill, op. cit., p. 296.

Two fine large specimens of this rare species are in the collection.

The largest is 5·80 inches broad and 2·10 high. It was previously known to me only from Panama Bay and San Salvador.

Tripneustes depressus A. Ag.; Verrill, op. cit., p. 375.

Of this large species there were 19 specimens, with their spines partially preserved. They are quite variable in form, but mostly even more elevated than ordinary specimens of *T. ventricosus.* Some are conical, others broadly rounded above. The name, therefore, is a decided misnomer. The largest spines on the upper surface of the largest specimen are ·45 of an inch long, ·04 in diameter, and rapidly taper to the acute point; those of the lower surface are often ·60 of an inch long, ·04 in diameter, tapering but little, the end blunt.

Several specimens give the following proportions:

Diameter, (inches)	5·80	5·40	5·35	5·25	5·10	4·90	4·75	4·60
Height,	3·00	3·40	2·90	3·25	2·85	2·65	2·85	2·80

ASTROIDEA.

Pentaceros occidentalis Verrill.

Oreaster occidentalis Verrill, op. cit., p. 278, 1866.

Of this hitherto rare species there are 21 specimens of various sizes. They show but little variation except that due to age or state of preservation. Some specimens are so dried as to leave the disk and rays plump and rounded above, while in others the interradial spaces are so shrunken as to make both the rays and disk angular. In some most of the upper and part of the lower marginal plates bear small obtuse spines or tubercles; in others there are few or none of these; the two smallest specimens have none, though others scarcely larger, have quite a number. The smallest specimen has the longer radius 1 inch; the shorter ·50. This, however, has nearly the form and all the essential characters of the adult, though the spines and tubercles are less numerous.

The name of the genus, *Pentaceros* Gray, has priority over *Oreaster* M. & Tr., which was substituted on the ground that the former was in use among fishes,* which I have been able to confirm, although Mr. A. Agassiz adopts it.

Among the other starfishes are *Gymnasteria spinosa* Gray (large); *Amphiaster insignis* Verrill, *Nidorellia armata* Gray, *Ophidiaster pyrimidatus* Gray, *Linckia bifascialis* Gray, *Acanthaster Ellisii* Verrill, *Mithrodia Bradleyi* Verrill, etc.

Corals.

Fungia elegans Verrill, sp. nov.

Coral when young regular and round, often becoming slightly oval; when adult usually more or less angular, the edge plicated, forming six to twelve lobes. The upper surface becomes very convex in mature specimens and the lower surface deeply concave and covered with very numerous, fine, subequal, elevated costæ, which are finely dentate on the outer half, becoming nearly entire and very faint toward the center, which usually shows the scar where attached when young. Septa thick and rather crowded, very unequal, the six primaries very prominent and thick at the inner end; those of succeeding cycles successively shorter and less elevated. Edges of septa unevenly crenulate, or finely dentate. Columella slightly developed, loosely spongy; median fosette small, narrow, elongated, the two septa in the direction of its longer diameter much less elevated and thinner than the rest. Trabiculæ stout, conspicuous, often coalescing into continuous transverse plates.

The smallest unattached specimens are ·90 of an inch broad by ·35 high; ordinary specimens are 1·90 broad by 1·10 high; the largest 2·35 by 1·20.

This is a small and very distinct species, remarkable as the first one of the genus described from America.

Among the other corals are *Pocillipora capitata* V., *P. capitata, var. porosa* V., *Cœnopsammia tenuilamellosa* E. & H., *Porites* (two species), *Stephanaria stellata* V., *Callipodium Pacificum* V., *Eugorgia aurantiaca* V., *E. nobilis, var. excelsa* V., *Leptogorgia rigida* V., *L. Agassizii* V., *L. media* V., *Muricea austera* V., *M. appressa* V., etc. Most of these are represented by numerous large and beautiful specimens.

* Cuvier and Val., vol. iii, p. 30, 1828; Gunther, Catal. Fishes British Museum, i, p. 212.

ART. XIV.—*Note on the Generic relations and Synonymy of the Common Sea-urchin of New England* (*Euryechinus Drobachiensis* Verrill); by A. E. VERRILL.

THIS common sea-urchin, which is found upon the northern coasts of Europe, and both upon the Atlantic and Pacific coasts of northern America, was referred to the genus *Echinus* by all writers up to 1846, but under various specific names: *E. Dröbachiensis* Müll., *E. neglectus* Lam., *E. granularis* Say, *E. chlorocentrotus* Brandt, etc. Prof. Agassiz, in the introduction to his monograph of the Scutellidæ, p. 7, 1841, proposed several new subdivisions of *Echinus*, merely giving generic names and citing "les types." Among these was *Toxopneustes* with "*E. pileolus*" as its type. But afterward, in the introduction to Valentin's Anatomy of the genus *Echinus*, Dec., 1841, he revised the genus then known as *Echinus*, and made many judicious and necessary changes. At that time he separated and characterized the genera, *Temnopleurus*, *Tripneustes*, *Amblypneustes*, *Holopneustes*, *Stomopneustes*, and *Toxopneustes*.* For the last he here takes for type, the *Echinus tuberculatus*. The genus *Echinus* he restricted (p. ii) so as to include only "the species near *Echinus esculentus*, and which have, like it, the ambulacra formed of several arched series of pores disposed in pairs." To this group he referred all the European species, including not only *E. Melo*, *E. esculentus*, *E. Flemingii*, *E. granularis*, *E. brevispinosus*, *E. æquituberculatus*, *E. miliaris*, etc., but also *E. neglectus* (*Dröbachiensis*) *and E. lividus*, which now constitute my genus *Euryechinus*. It is plain, therefore, that at that time the genus *Toxopneustes* had nothing to do with such species as I have called *Euryechinus*. Later, in the Catalogue Raisonné, 1846, *Toxopneustes* (sub-genus) was extended so as to include, in addition to the typical species, several previously placed by Agassiz in *Echinus*. Still later Desor removed part of the species thus erroneously added, under the name of *Sphærechinus*, but he still left in it *Dröbachiensis* and *lividus*. Therefore as these were evidently generically distinct from the typical *Toxopneustes* and had received no generic name, I formerly proposed that of *Eurychinus*,† and gave my reasons in detail.

* The following is the description: Le genre *Toxopneustes* a des ambulacres formés de séries arquées de doubles pores, convergeant vers le milieu des aires et séparées par des rangées parallèles de petits pores. Chaque série arquée se compose de six à neuf paires de pores. Vers la bouche il y en a moins; mais elles sont plus rapprochées. Les tubercules des séries principales sont assez grands; l'ouverture inférieure du test offre dix échancrures peu profondes. Je prends pour type de ce genre l'*Echinus tuberculatus*; j'en connais quelques espèces inédites."

† Proc. Boston Society Nat. Hist., x, p. 341, 1866, and Transact. Connecticut Acad., i., p. 394, 1867.

To any unprejudiced person it will be evident from this statement that, as left by Desor after his latest restrictions, *Toxopneustes* included two generic groups, one of which was the original and typical *Toxopneustes* of 1841, the other an unnamed genus, (*Euryechinus*). The fact that Mr. A. Agassiz, apparently overlooking the true state of the case, renamed in 1862 the original *Toxopneustes* section, calling it *Toxocidaris*, cannot affect the matter in the least, since in this instance there can be no doubt as to which group was originally designated by the name, *Toxopneustes*. Yet Mr. Agassiz in a recent paper* goes considerably out of his way to bring up this matter again, and inserts the following note under *Echinometra Michelini*:

"I cannot see the propriety of the changes made by Verrill in the limitation of Toxopneustes, by substituting Euryechinus for a group of Echini, which are perfectly well known by all writers on Echinoderms as Toxopneustes. For the following reasons it seems to me, even granting all his premises, that the changes he proposes are not warranted. The type of the genus at the time the Monog. d. Echinides was written was never used in the restricted sense now common, but was coextensive with a group of species. When Toxopneustes was first proposed, it was applied to a so-called typical species which future investigations showed did not belong to the genus. The author took the earliest opportunity possible to point out his mistake by substituting for it another type, and giving a description which *applies not only to Toxocidaris as Mr. Verrill would have it, but also to all the species since removed as Sphærechinus by Desor.* Desor, who had edited the Catalogue Raisonné, and probably knew accurately what group of Echini was defined as Toxopneustes, was the first, in his Synopsis, to limit Toxopnuestes by removing from it certain species as Sphærechinus, and restrict Toxopneustes to such forms as (*T. neglectus*) *T. drobachiensis* Ag., but still including the species which I have since, in the Bulletin of the Museum, separated as Toxocidaris. All these limitations, even were they not accepted, have the priority over a similar limitation which Verrill makes twelve years after a proper limitation of the genus has been recognized, and eighteen years after a mistake (upon which Mr. Verrill bases the whole of his proposed changes) has been corrected by the author himself; nothing, moreover, is gained in accuracy by the change proposed by Verrill, *T. tuberculatus* being probably only a nominal species, and one concerning which we have, at any rate, no authentic information sufficient to form the basis of a sweeping reform. At the present rate of retrospective application of the laws of priority, we are fast drifting into the most absurd anachronism by applying the present condition of our knowledge of any group to works written twenty or thirty years ago in an entirely different spirit, when the idea of type, genera, etc., had a totally distinct signification from what it has at the present day."

A formal reply to this is perhaps unnecessary, yet I would venture the following remarks:

* Bulletin of the Museum of Comp. Zoölogy, No. 9, p. 260, November, 1869.

1. I am not aware that any other zoölogist has denied the validity of "type-species" (especially when particularly designated as such) in works even much earlier than 1841.

2. Even if the original description of *Toxopneustes* would include *Sphærechinus*, yet, as I have explained above, Agassiz himself referred the species of the latter to *Echinus* in the same article, *and he probably knew accurately what group was defined as Toxopneustes at that time.*

3. All the "limitations" by Desor, which are said to have priority over mine, I have always admitted and adopted.

4. I do not base any changes upon "a mistake," for whether "*E. pileolus*" or "*E. tuberculatus*" be taken as the type of *Toxopneustes*, the claims of *Euryechinus* remain unaffected, and I have, when making the change, distinctly stated my conviction that the reference to *E. pileolus* should not be regarded, and have adopted *Toxopneustes* in place of *Toxocidaris* A. Ag. (See Trans. Conn. Acad.).

5. Whether *E. tuberculatus* be "a nominal species" does not affect the character of the genus to which it belongs.

6. I know of no more fruitful source of confusion than the transferring of a name from the group to which it originally belonged to another totally distinct from it, and re-naming the first group.

7. Had Mr. Agassiz, before naming *Toxocidaris*, looked a little more closely into the early synonymy of *Toxopneustes*, all confusion in this case might have been avoided.

8. The fact that there is a *future* for zoölogical nomenclature, as well as a *past*, should not be forgotten, nor that a just and reasonable application of the universally recognized law of priority is the surest way of securing future stability.

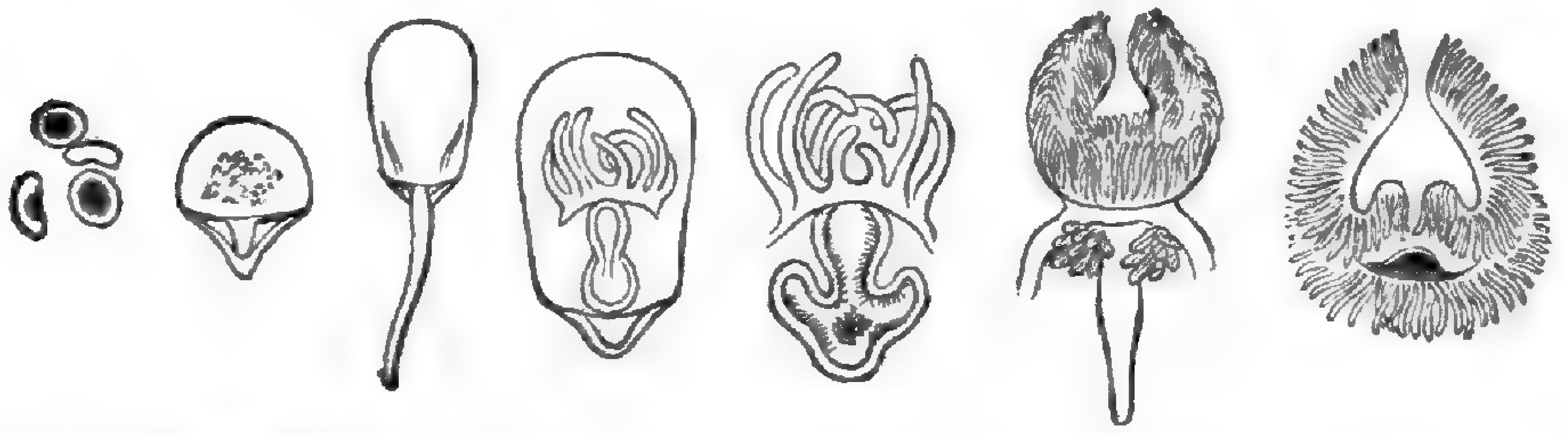
Art. XV.—*On the Early Stages of Brachiopods;* by E. S. Morse.*

The writer made a visit to Eastport, Maine, early in the summer, for the purpose of discovering the early stages of a species of Brachiopod (*Terebratulina septentrionalis* Couth.) so abundant in those waters. As little has been known regarding the early stages of this class of animals the facts here presented will be of interest, as settling beyond a doubt their intimate relations with the Polyzoa. As the subject will be fully presented at the meeting of the American Association, only the more important features will be mentioned here. In a few individuals the ovaries were found partially filled with eggs,

* From the American Naturalist, September, 1869.

The eggs (fig. 1) were kidney-shaped, and resembled the statoblasts of Fredericella. No intermediate stages were seen between the eggs and the form represented in fig. 2. This

1. 2. 3. 4. 5. 6. 7.



stage recalled in general proportions Megerlia or Argiope in being transversely oval, in having the hinge-margin wide and straight and in the large foramen. Between this stage and the next the shell elongates until we have a form remarkably like Lingula (fig. 3), having, like Lingula, a peduncle longer than the shell, by which it holds fast to the rock. It suggests also in its movements the nervously acting Pedicellina.

In this and the several succeeding stages, the mouth points directly backward (forward of authors), or away from the peduncular end (fig. 4), and is surrounded by a few ciliated cirri, which forcibly recall certain Polyzoa. The stomach and intestine form a simple chamber, alternating in their contractions and forcing the particles of food from one portion to the other. At this time also the brownish appearance of the walls of the stomach resembles the hepatic folds of the Polyzoa. Fig. 5 shows a more advanced stage, where a fold is seen on each side of the stomach; from this fold the complicated liver of the adult is developed, first, by a few diverticular appendages, as seen in fig. 6.

When the animal is about one-eighth of an inch in length the lophophore begins to assume the horse-shoe shaped form of Pectinatella and other high Polyzoa. The mouth at this stage (fig. 6) begins to turn toward the dorsal valve (ventral of authors), and as the central lobes of the lophophore begin to develop, the lateral arms are deflected, as in fig. 7. In these stages an epistome is very marked, and it was noticed that the end of the intestine was held to the mantle by attachment, as in the adult, reminding one of the *funiculus* in the *Phylactolæmata*. No traces of an anus were discovered, though many specimens were carefully examined under high powers for this purpose, the intestine of the adult being repeatedly ruptured under the compressor without showing any evidence of an anal aperture.

ART. XVI.—*On the existence of a Crocodile in Florida;* by JEFFRIES WYMAN, M.D.

IT has been shown by different paleontologists, especially by Dr. Leidy and Prof. Cope, that several species of Crocodilians existed in North America during the Cretaceous and Miocene periods, all of which became extinct. At the present time two living species of true Crocodiles, viz: *C. acutus* and *C. rhombifer*, are known in South America, and both range as far north as Cuba and San Domingo, but we have not been able to find a record of the presence of either of them within the limits of the United States, the Alligator being the only representative of the family to which it belongs.

While a guest of J. M. Forbes, Esq., on board the yacht Azalea, I had an opportunity of visiting Key Biscayne Bay in March, 1869, and while there Mr. William H. Hunt, of Miami, presented me the cranium here described. The animal to which it belonged, as I was told by the person who killed it, was shot near the mouth of the Miami river, which opens into the above mentioned bay. I was also informed that another had been killed in the same neighborhood.

The length of the head (from the alveoli of the incisors to the end of the occipital condyle) is 462^{mm}, and the greatest breadth 191^{mm}. The whole number of teeth is 68, viz: $\frac{19-19}{15-15}$; in the upper jaw the 4th and 10th, and in the lower the 4th and 11th are the longest. The first 12 teeth above and the first 11 below have the enamel fluted, and in both jaws the teeth behind these are marked with finely reticulated grooves. These hinder teeth are shorter and blunter, and thus more closely resemble the teeth of the alligator. The upper jaw is strongly convex and protuberant along the back of its middle portion.

When compared with a somewhat larger head of the *C. acutus* from South America (length 462^{mm}, breadth 211^{mm}), the Florida specimen closely agrees with it in the above as well as some other particulars. The following table shows some differences, however, relating chiefly to the proportion of the breadth to the length. In the table the length is assumed to be 1·000, and the measurements are in fractions of the length.

	South America.	Florida.
Greatest breadth of cranium	0·456	0·483
Length of palatine opening	0·214	0·210
Breadth " "	0·075	0·086
Breadth across pterygoids	0·300	0·313
Breadth at 4th tooth	0·162	0·169
Breadth at 10th tooth	0·218	0·235
Breadth at contraction behind 5th tooth	0·123	0·131
Breadth at contraction behind 12th tooth	0·190	0·210

In the South American specimen the markings of the surface of the bone consist chiefly of pits, while in the Florida specimen the markings are more in the form of grooves. In the first the parietal foramina are separated by a flat surface of bone 15 millimeters wide, while in the second there is only a blunt ridge. In this last also the lower jaw is somewhat longer, and its hinder part less recurved. The Florida specimen being the smallest is assumed to be the youngest; the differences of proportion above referred to may therefore depend upon age, as in young individuals the breadth is relatively greatest. In view of this we find no sufficient reason for considering the Florida specimen as belonging to any other than the sharp-nosed species (*C. acutus*). This conclusion is still further supported by a portion of the skin of the neck, which is preserved, and in which the nuchal plates are the same as in the species just named.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *On the emission and absorption of heat radiated at low temperatures.*—Magnus has communicated to the Royal Academy of Sciences in Berlin an important memoir on radiant heat, the principal results of which are, in the author's own words, as follows:

(1.) Different substances heated to 150° C. radiate different kinds of heat.

(2.) There are bodies which radiate only one kind of heat and others which radiate many kinds.

(3.) Perfectly pure rock salt belongs to the first class. Just as its ignited vapor or that of one of its constituents, sodium, sends out only one color, so this, even at 150° C., radiates only one kind of heat. It is monothermic, as its vapor is monochromatic.

(4.) Rock salt absorbs the heat radiated by rock salt in great quantity and more strongly than that of sylvin (KCl) and other kinds of heat. It therefore does not, as Melloni and Knoblauch suppose, permit all kinds of heat to pass through with equal facility.

(5.) The absorption of heat by rock salt increases with the thickness of the absorbing plate.

(6.) The great diathermancy of rock salt does not depend upon a small absorbing power for different kinds of heat, but upon the fact that it only radiates a single kind of heat, and consequently also absorbs only this, and that almost all other bodies at the temperature of 150° C. send out heat which contains only a small portion or none of the rays which are radiated by rock salt.

(7.) Sylvin behaves like rock salt but is not monothermic in an equal degree. In this also we trace the analogy with its own ignited vapors or with those of potassium, which, as is well known, gives an almost continuous spectrum.

(8.) Fluorspar almost completely absorbs pure rock salt heat. We ought therefore to expect that the heat which it radiates should be strongly absorbed by rock salt. Nevertheless 70 per cent of it pass through a rock salt plate of 20^{mm} thickness. With reference to the sum of the heat which fluorspar radiates, which is more than three times greater than that from rock salt, this phenomenon may be explained, but the subject requires further investigation.

(9.) If it were possible to form a spectrum of the heat radiated at 150° C., this spectrum, if rock salt were the radiating body, would contain only one band. If sylvin were used for radiating, the spectrum would be more extended, but would still occupy only a small portion of the spectrum which would be produced by the heat radiated from lamp black.—*Pogg. Ann.*, cxxxviii, 333.

W. G.

2. *On the reflection of heat at the surface of fluorspar and other bodies.*—In a second paper, MAGNUS remarks that the newly discovered property of rock salt and other substances of sending out at 150° C. rays of but one or but few wave lengths makes it possible to institute experiments on the reflection of non-metallic surfaces. The results of experiments have distinctly shown that such surfaces reflect different kinds of heat, or heat rays of different wave lengths, in very different degrees. A remarkable illustration is furnished by fluorspar. Of the heat radiated by different substances and received at an angle of 45°, quantities differing but little in amount are reflected by the following bodies:

Silver,	from	83 to 90	per cent.
Glass,	"	6 to 14	"
Rocksalt,	"	5 to 12	"
Fluorspar,	"	6 to 10	"

But fluorspar reflects 28–30 per cent of the heat from rock salt, while silver, glass and rock salt reflect no greater proportion of this than of other kinds of heat. Fluorspar reflects from 15 to 17 per cent of the heat from sylvin, which confirms the result deduced from the transmission of heat. To an eye which could distinguish the different wave lengths of heat, as well as the colors of light, fluorspar would appear brighter than other substances if all were illuminated at the same time by rays from rock salt. The same would be the case if rays from sylvin were incident, only in this case the fluorspar would be less bright. As the experiments of Magnus established the fact that even at 150° C. different substances send out very different kinds of heat, it follows that in every space an extraordinary number of different wave lengths are continually crossing each other. This variety of intersection is further greatly increased by the elective reflection which takes place at the different surfaces. An eye which could distinguish different wave lengths of heat, like the colors of light, would see all objects in the greatest variety of colors without any sensible heating of the objects themselves.—*Pogg. Ann.*, cxxxviii, 174. W. G.

3. *On the heat of the stars.*—Mr. Huggins has endeavored to determine whether a measurable amount of heat is radiated from the fixed stars. The incident rays were received upon the object-glass of a telescope of 8 inches aperture, in the focus of which was placed the surface of a thermo-electric pile consisting, for stars, of one or two pairs, for the moon, of 24 pairs. An astatic galvanometer of great delicacy was employed. The thermo-electric pile was enclosed in casings of pasteboard stuffed with cotton so as to exclude all changes of temperature as much as possible. The author describes the minute precautions taken, for which we must refer to his paper. The telescope could be directed to a star by means of the finder, the needle being at rest, and the image of the star kept by clockwork upon the face of the pile. It was found that the needle almost always began to move as soon as the image fell upon the pile, and that when the telescope was then directed to the sky near the star the needle usually began, after a minute or two, to return to its original position. From 12 to 20 observations were made upon the same star, and these observations repeated on other nights. In this manner observations of Sirius gave a deviation of the needle of 2°; those of Pollux 1½°. Castor gave no deviation; Regulus a deviation of 3° and Arcturus in 15 minutes also 3°.

Observations of the full moon did not give corresponding or reliable results. The results obtained with the stars are not strictly comparable, as it is uncertain whether the sensitiveness of the galvanometer was always the same.—*Proceedings of the Royal Society*, No. 109, 1869. W. G.

4. *On new sulphur salts.*—Schneider has discovered and described a remarkable series of sulphur salts which are formed by simply fusing together certain metals in the form of powder with sulphur and potassic carbonate. Sulphid of iron and potassium is formed by fusing together 1 part of pulverized iron, 6 parts of dry potassic carbonate and 6 parts of sulphur, until the mass has become uniformly and quietly fused. Water diffuses from the cooled mass much potassic sulphite and hyposulphite and leaves the new compound in crystals. The new salt has the formula $K_2S . Fe_2S_3$ or atomistically,

$$\begin{array}{c} S-K \\ | \\ S{=}Fe_2^{vi}{=}S \\ | \\ S-K \end{array}$$

It forms long flexible needles of brilliant luster and purple brown color. At ordinary temperatures it is permanent. Acids even when very dilute decompose this body easily with evolution of hydric sulphid and separation of sulphur. Heated in a current of hydrogen it loses one atom of sulphur preserving its luster and crystalline structure. The new compound has the formula K_2S. $2FeS$, or,

$$\begin{array}{l} S-K \\ | \\ Fe^{iv}{=}S \\ | \\ S-K \end{array}$$

Schneider considers it probable that in fusing ferric oxyd with potassic or sodic carbonate similar compounds, containing oxygen in place of sulphur, are formed.

When bismuth is used in the above process in place of iron, delicate light steel gray brilliant crystalline needles are formed which have the formula $Bi_2K_2S_4$, or,

$$\begin{array}{c} S-K \\ | \\ S{=}Bi_2{}^{vi}{=}S \\ | \\ S-K \end{array}$$

This compound is easily and completely decomposed by chlorhydric acid with evolution of hydric sulphid. The author has obtained similar compounds containing copper, iron and copper, and platinum. They are beautifully crystalline and will form the subject of future more extended description.—*Pogg. Ann.*, B. 136, p. 460.

W. G.

5. *On a new series of crystallized platinum compounds.*—By the action of stannous chlorid upon platinic chlorid, SCHNEIDER obtained a substance having probably the empirical formula, $Na_2Pt_2Sn_2O_6$, which though not yet thoroughly studied, forms the starting point from which the author obtained some very remarkable new compounds. When an intimate mixture of 4 parts of the above compound, 6 of potassic carbonate and 8 or 10 of sulphur are fused together, and the cold fused mass is treated with water, a cochineal red crystalline powder remains, easily obtained pure by washing. Under the microscope this compound is seen to consist of sharply defined six-sided tables of an almost metallic luster, which vary in color, according to their thickness, from light yellowish red to deep garnet red. The crystals are insoluble in water and unchanged by it. Dilute chlorhydric acid colors them at once dark greyish-black and takes up potash, but without evolution of any gas whatever. The residue is free from potash and is not attacked by boiling chlorhydric or nitric acid and but slowly by aqua regia. The original red body when heated in a current of hydrogen loses $\frac{2}{3}$ of its sulphur. The residue then gives up potash to chlorhydric acid, and the residue thus obtained loses all the remaining sulphur, when heated in hydrogen, and leaves a mixture of tin and platinum. From this it appears that the last $\frac{1}{3}$ of the sulphur is retained through the influence of the potash. The direct expression of the results of the analysis of the red compound is $Sn\,O\,K\,Pt_3S_6$. The simplest atomistic formula appears to be the following:

$$\begin{array}{ccc} Pt^{ii} & - & S \\ | & & | \\ Sn^{iv} & = & S_2 \\ | & & | \\ K_2 & & \Theta \\ | & & | \\ Pt^{iv} & = & S_2 \\ | & & | \\ Pt^{ii} & - & S \end{array}$$

The action of chlorhydric acid on this salt is then readily explained, since, without writing the whole formula, we see at once that

$K_2\Theta+2HCl=H_2\Theta+2KCl$. The residue must therefore have the formula,

$$\begin{array}{ccc} Pt^{ii} & - & S \\ | & & | \\ Pt^{iv} & = & S_2 \\ | & & | \\ Sn^{iv} & = & S_2 \\ | & & | \\ Pt^{ii} & - & S \end{array}$$

The action of hydrogen upon the new compound may then be expressed by the equation:

$$\begin{array}{ccc} Pt^{ii} & - & S \\ | & & | \\ Pt^{iv} & = & S_2 \\ | & & | \\ K_2 & & \Theta \\ | & & | \\ Sn^{iv} & & S_2 \\ | & & | \\ Pt^{ii} & - & S \end{array} +8H=4H_2S+ \begin{array}{ccc} Pt & & \\ & & \\ Pt^{ii} & - & S \\ | & & | \\ K_2 & & \Theta \\ | & & | \\ Sn^{ii} & - & S \\ & & \\ Pt & & \end{array}$$

Hence the residue consists of metallic platinum mixed with a simple oxy-sulpho salt in which tin and platinum are now diatomic. The action of chlorhydric acid on the oxy-sulpho salt may be represented by the equation:

$$\begin{array}{ccc} Pt^{ii} & - & S \\ | & & | \\ K_2 & & \Theta \\ | & & | \\ Sn^{ii} & - & S \end{array} +2HCl=H_2\Theta+2KCl+ \begin{array}{ccc} Pt & - & S \\ | & & | \\ Sn & - & S \end{array}.$$

The last term when heated in hydrogen then gives hydric sulphid and a mixture of tin and platinum. The corresponding sodium salt may be obtained in the same manner and closely resembles the potassic compound.—*Pogg. Ann.*, cxxxvi, p. 105. W. G.

7. *Contributions to a knowledge of conjugate bodies in inorganic Chemistry.*—Under this title Blomstrand has communicated a number of interesting notices of what may be termed atomic aggregation. Platino-cyanid of potassium takes up two atoms of iodine with great facility, forming an iodo-platinocyanid, $K_2Cy_4Pt+I_2=K_2Cy_4PtI_2$, which crystallizes in large brilliant brown crystals. Chlorine and bromine displace the iodine, forming a corresponding chlorid and bromid, the former being the salt described by Knop. The corresponding salts of other positive metals are easily obtained. Iodine in like manner unites directly with auro-cyanid of potassium forming long brilliant brown needles, KCy_2AuI_2. Similar compounds of chlorine and bromine also exist. Double nitrite of platinous oxyd and platinum, $K_2Pt(N\Theta_2)_4$, also takes up chlorine and bromine readily, forming yellow crystalline salts which the author formulates as follows: $(K-\Theta-N\Theta=N\Theta-\Theta)_2PtCl_2$ and $(R-\Theta-N\Theta=N\Theta-\Theta)_2PtBr_2$.

Blomstrand regards the ammonia-nitrite of Lang $(NH_3)_2Pt.(N\Theta_2)_2$ as an intermediate term between the ammonia and the nitrous series and gives it the formula $(H_3N=N\Theta-\Theta)_2Pt$. This salt also unites with chlorine and bromine, forming very beautiful crystals. The bromid has the formula $(H_3N{=}N\Theta-\Theta)_2PtBr_2$ and is the bromid of a true base in which the bromine may be replaced by oxygen acids. The author terms the base plato-nitrosamin. The paper contains many interesting and instructive illustrations of the author's peculiar views of the qualitative influence produced on compounds by the substitution of electro-positive or electro-negative elements—views which are set forth with much clearness and force in his recently published work "Die Chemie der Jetztzeit."—*Berichte der Deutschen Chemischen Gesellschaft*, 1869, No. 9, p. 202. W. G.

II. MINERALOGY AND GEOLOGY.

1. *On the Surface Geology of the Basin of the Great Lakes, and the Valley of the Mississippi;* by Dr. J. S. Newberry, (Ann. Lyc. Nat. Hist. N. York, ix, 213, 1869).—In this important paper the author, after reviewing the general facts with regard to the drift, remarks as follows on the history of the era:

"1st.—That in a period probably synchronous with the glacial epoch of Europe,—at least corresponding to it in the sequence of events,—the northern half of the continent of North America had a climate comparable with that of Greenland; so cold, that wherever there was a copious precipitation of moisture from oceanic evaporation, that moisture was congealed and formed glaciers which flowed by various routes toward the sea.

"2nd.—That the courses of these ancient glaciers corresponded in a general way with the present channels of drainage. The direction of the glacial furrows proves that one of these ice rivers flowed from Lake Huron, along a channel now filled with drift, and known to be at least 150 feet deep, into Lake Erie, which was then not a lake, but an excavated valley into which the streams of northern Ohio flowed, 100 feet or more below the present lake level. Following the line of the major axis of Lake Erie to near its eastern extremity, here turning northeast, this glacier passed through some channel on the Canadian side, now filled up, into Lake Ontario, and thence found its way to the sea either by the St. Lawrence or by the Mohawk and Hudson. Another glacier occupied the bed of Lake Michigan, having an outlet southward through a channel—now concealed by the heavy beds of drift which occupy the surface about the south end of the lake—passing near Bloomington, Ill., and by some route yet unknown reaching the trough of the Mississippi, which was then much deeper than at present.

"3rd.—At this period the continent must have been several hundred feet higher than now, as is proved by the deeply excavated channels of the Columbia, Golden Gate, Mississippi, Hudson, &c., which could never have been cut by the streams that now occupy them, unless flowing with greater rapidity and at a lower level than they now do."

After further explanations he takes up the subject of the *Drift Deposits.*

"The Drift deposits which cover the glacial surface, consisting of fine clays below, sands and gravel above, large transported boulders on the surface, and the series of lake ridges (beaches) over all, form a sequence of phenomena of which the history is easily read.

"The lower series of blue or red clays—the 'Erie clays' of Sir William Logan—over a very large area, rest directly on the planed and polished rock surfaces. These clays are often accurately stratified, were apparently deposited in deep and generally quiet water, and mark a period when the glacial ice-masses, melted by a change of climate, retreated northward, leaving large bodies of cold, fresh water about their southern margins, in which the mud produced by their grinding action on the paleozoic rocks of the Lake District was first suspended and then deposited.

"On the shores of Lake Erie these clays contain no boulders, and very few pebbles, while farther north and west boulders are more abundant. This is precisely what might be expected from the known action of glacial masses on the surfaces over which they pass. Their legitimate work is to grind to powder the rock on which they rest; an effect largely due to the sand which gathers under them, acting as emery on a lead wheel. The water flowing from beneath glaciers is always milky and turbid from this cause. Rocks and boulders are sometimes frozen into glaciers, and thus transported by them, but nearly all the boulders carried along by a glacier are such as have fallen from above; and a moraine can hardly be formed by a glacier except when there are cliffs and pinnacles along its course.

"In a nearly level country, composed of sedimentary rocks passed over by a glacier, we should have very little débris produced by it, except the mud flour which it grinds.

"The Erie clays would necessarily receive any gravel or stones which had been frozen into the ice, either as scattered pebbles or stones, distributed to some distance from the glacial mass by floating fragments of ice, or as masses of frozen gravel, or larger and more numerous boulders near the glacier. In some localities torrents would pour from the sides and from beneath the glacier, so that here coarse material would alone resist the rapid motion of the water, and the stratification of the sediments would be more or less confused."

The author next mentions the evidence of a general subsidence, greater to the north, and an ameliorated climate, as succeeding to the Glacial era; and then makes the following observations on the "*Yellow Sands and Surface Boulders.*"

"I have mentioned that on the Erie clays are beds of gravel, sand and clay, and over these again great numbers of transported boulders, often of large size and of northern and remote origin.

"These surface deposits have been frequently referred to as the direct and normal product of glacial action, the materials torn up and scraped off by the great ice ploughs in their long journeys from the North; in fact, as some sort of huge terminal and lateral moraines. I have, however, disproved, as I think, this theory of their transportation in a paper published some years since (Notes on the Surface Geology of the Basin of the Great Lakes. Proc. Bost. Nat. Hist. Soc., 1863), in which it is urged that the continuous sheet of the Erie clays upon which they rest, and which forms an unbroken belt between them and their place of origin, precludes the idea that they have been transported by any ice-current or rush of water moving over the glacial surface: as either of these must have torn up and scattered the soft clays below.

"There is, indeed, no other conclusion deducible from the facts than that these sands, gravels, granite and greenstone boulders—masses of native copper, &c., which compose the superficial Drift deposits—have been *floated* to their resting places, and that the floating agent has been ice, in the form of *icebergs;* in short, that these materials have been transported and scattered over the bottom and along the south shore of our ancient inland sea just as similar materials are now being scattered over the banks and shores of Newfoundland.

"If we restore in imagination this inland sea, which we have proved once filled the basin of the lakes, gradually displacing the retreating glaciers, we are inevitably led to a time in the history of this region when the southern shore of this sea was formed by the highlands of Ohio, &c., the northern shore a wall of ice resting on the hills of crystalline and trappean rocks, about Lake Superior and Lake Huron.

"From this ice-wall masses must from time to time have been detached,—just as they are now detached from the Humboldt Glacier,—and floated off southward with the current, bearing in their grasp sand, gravel and boulders—whatever composed the beach from which they sailed. Five hundred miles south they grounded upon the southern shore; the highlands of now Western New York, Pennsylvania and Ohio, or the shallows of the prairie region of Indiana, Illinois and Iowa; there melting away and depositing their entire loads—as I have sometimes seen them, a thousand or more boulders on a few acres, resting on the Erie clays and looking in the distance like flocks of sheep—or dropping here and there a stone and floating on east or west, till wholly dissipated.

"These boulders include representatives of nearly all the rocks of the Lake Superior country, conspicuous among which are granites with rose-colored orthoclase, gray gneiss, and diorites, all characteristic of the Laurentian series; hornblendic rocks, massive or schistose, and dark greenish or bluish siliceous slates, probably from the Huronian; dolorites and masses of native copper apparently from the Keweenaw Point copper region.

"In the Drift gravels I have found pebbles and small boulders of nearly all the paleozoic rocks of the lake basin, containing their characteristic fossils, viz: the Calciferous Sandrock with *Maclurea,* Trenton and Hudson with *Ambonychia radiata, Cyrtolites ornatus,* Medina with *Pleurotomaria litorea,* Corniferous with

Conocardium trigonale, *Atrypa reticularis*, *Favosites polymorpha*, Hamilton with *Spirifer mucronatus*, &c.

"The granite boulders are often of large size, sometimes six feet and more in diameter, and generally rounded.

"Along the southern margin of the Drift area, especially on the slopes of the highlands of Northern Ohio, the Drift sands and gravels are of considerable thickness, forming hills of 100 feet. or more in height, generally stratified, but often without any visible arrangement. These deposits are very unevenly distributed, with a rolling surface frequently forming local basins, which hold the little lakelets or sphagnous marshes so characteristic of the region referred to. These are the beds to which I have alluded as constituting, in the opinion of some geologists, a great glacial moraine, but from the fact that they are locally stratified, and overlie the older blue clays, I have regarded them as transported, not by glaciers but by icebergs.

"Possibly some part of this Drift material may have accumulated along the margin of the great glacier, moved by its agency; but in that case we should expect to find in it abundant fragments of the rocks which outcrop in the region under consideration, whereas I have rarely, if ever, seen in these Drift gravels any representatives of the rocks underlying the South margin of the lake basin.

"By whatever agency transported, the Drift gravels have, like the boulders, for the most part come from some remote point at the North, and were once spread broadcast along the southern shore of the inland iceberg-bearing sea.

"In the retreat of the shore line during the contraction of the water surface down to its present area, every part of the slope of the southern shore, between the present water surface and the highest lake level of former times, *i. e.*, all within a vertical height of 300 feet or more, must in turn have been submitted to the action of the shore waves, rain and rivers, by which if, as is probable, the retrograde movement of the water line was slow, these loose materials would be rolled, ground, sorted, sifted and shifted, so that comparatively little would be left in its original bedding; the fine materials, clay and sand, would be washed out and carried farther and still farther into the lake basin, and spread over the bottom, to form, in short, the upper sand layers of the Drift."

Dr. Newberry closes with remarks on the origin of the great lakes, in which he states his conclusion that:

"1st. Lake Superior lies in a synclinal trough, and its mode of formation therefore hardly admits of question, though its sides are deeply scored with ice-marks, and its form and area may have been somewhat modified by this agent.

"2d. Lake Huron, Lake Michigan, Lake Erie, and Lake Ontario, are excavated basins wrought out of once continuous sheets of sedimentary strata, by a mechanical agent, and that ice or water, or both."

2. *On the Nature and Cause of the Glacial Climate*; by JOSEPH JOHN MURPHY, Esq., F.G.S. (Q. J. Geol. Soc., xxv, 350, 1869).—In the present paper I purpose to show how far I agree with, and where I differ from, Mr. Croll as to the views on the cause of the glacial climate set forth in his paper in the 'Philosophical Magazine' for August, 1864.

Mr. Croll's conclusions may be stated in the three following propositions:—

1. A glacial period occurs when the eccentricity of the earth's orbit is at a maximum, and the solstices fall when the earth is in perihelio and in aphelio.

2. Only one hemisphere, the northern or the southern, has a glacial climate at the same time.

3. The glaciated hemisphere is that of which the *winter* occurs in aphelio.

I agree with Mr. Croll as to the first two propositions, but differ as to the third. I believe that the glaciated hemisphere is that of which the *summer* occurs in aphelio.

The following propositions are self-evident when stated:—

When the eccentricity of the earth's orbit is very considerable, and the winter of either hemisphere occurs in perihelio and its summer in aphelio, the nearness of the sun in winter will cause a mild winter, and his remoteness in summer will cause a cool summer.

Conversely, in the opposite hemisphere at the same time, the winter will occur in aphelio and the summer in perihelio: the remoteness of the sun in winter will cause a cold winter, and his nearness in summer will cause a hot summer.

Suppose, for instance, that when the eccentricity of the earth's orbit is much greater than at present, the midwinter of the Northern hemisphere occurs in perihelio; then

the *Northern* hemisphere will have a *mild winter* and *cool summer*,
the *Southern* hemisphere will have a *cold winter* and *hot summer*.

So far (granting Mr. Croll's astronomical data, for which he cites Leverrier, and which I believe are indisputable) there is no room for doubt. I have now to discuss the question, what effect these diversities of climate will have in producing glaciation.

Mr. Croll thinks the hemisphere of *cold winter* will be the glaciated one. I think, on the contrary, the hemisphere of *cool summer* will be the glaciated one.

On this subject it is needless to attempt to make any deduction from theory. We have plenty of observed data; and I think I can show that they all go to prove a cool summer to be what most promotes glaciation, while a cold winter has, usually, no effect on it whatever.

Forbes, in his work on Norway and its Glaciers, p. 206, quotes "the excellent generalization of von Buch, that it is the temperature of the summer months which determines the plane of perpetual snow." This indeed is almost an identical proposition; for perpetual snow is snow that lies through the heats of summer; and it would appear obvious enough, had it not been frequently overlooked, that it must be the temperature of summer which, other things being equal, determines the level of summer snow.

But, according to the same authority (Forbes's 'Norway and its Glaciers,' p. 206), "another cause affecting exceedingly the level of the snow-line is the amount of snow which falls."

These laws are illustrated in detail by the following table. In constructing it I have assumed, what is tolerably near the truth, that the temperature of the hottest month of the year decreases in ascending at the rate of 1° F. for every 300 feet. The temperatures are taken, as accurately as I have been able to do it, from Dove's map. My authorities for the heights of the snow-line are, for the first four, Durocher as quoted by Mr. Hopkins in the 'Proceedings of the Geological Society' for Dec. 17, 1851, for the rest, Mrs. Somerville's 'Physical Geography,' p. 314. The temperatures are in degrees of Fahrenheit. The heights are in feet.

	Temperature of hottest month at sea level.	Height of 32° F. in hottest month.	Height of snow-line.
Pyrenees	74·5	12750	9300
Caucasus	77	13500	10300
Mont Blanc	72·5	12150	9000
Bernese Alps	72·5	12150	8800
Scandinavian Fjelde, 61° 43′ N	59	8100	5500
Mageroe, Norway, extreme north	45·5	4050	2160
Himalaya, about 31° N., *north side*	83·75	15525	16620
The same, " *south side*	83·75	15525	12980
Andes, near Quito	79·25	14175	15795
" 18° N.	81·5	14850	14772
" near Valparaiso	68	10800	12780
" 37° 40′ S.	63·5	9450	7960
Straits of Magellan	45·5	4050	3390

It is evident by this table that the snow-line rises above the line of 32° for the hottest month of the year where the snow-fall is small, and sinks below it where the snow-fall is great. In the Caucasus, the Alps, and the Pyrenees, the snow-line is about three-fourths of the height of the line of 32° for the hottest month of the year; in the Fjelde of Norway, about two-thirds; in the Peruvian and Chilian Andes above, but in Patagonia and Tierra del Fuego below; above, on the north side of the Himalaya, but below on the south side. These contrasts are all to be explained by the difference in the amount of snow-fall, which is greater on the south than on the north side of the Himalaya, greater in Patagonia and Tierra del Fuego than in Chilé and Peru, and probably greater, at least in winter, in Norway than in Central, Southern, or Eastern Europe.

The dependence of the height of the snow-line on summer temperature and on amount of snow-fall, to the exclusion of winter temperature, may be best shown, perhaps, by two extreme cases. The mean temperature of the Altai mountains (according to Mr. Hopkin's paper cited above) is below freezing; yet in consequence of the comparatively warm summer, and the small snow-fall, the height of the snow-line (Mrs. Somerville's 'Physical Geography,' p. 61) is about 6000 feet. On the Straits of Magellan, on the contrary, though the mean temperature is several degrees above freezing, the height of the snow-line (see table) is little more than half as much.

It is well known that, other things being equal, the magnitude of glaciers depends on that of the snow-fields in which they rise; and as of course any depression of the snow-line will enlarge the snow-field, it follows that the lower the snow-line the further will the glaciers descend below it. As a decrease of about 3° F. is due to every 1000 feet of ascent in the hottest month, it follows that a fall of temperature to that extent in the hottest month would lower the snow-line by about 1000 feet; and in many cases it is likely that the glaciers in such a case would descend 1000 feet further below the snow-line than at present, thus gaining a total increase of 2000 feet of descent. This might not have much effect on the climate of Central Europe, but it would have a very great effect in those high latitudes where the glaciers would reach the sea and give origin to icebergs; for we know that icebergs have great influence as transporters of cold.

In particular cases the effect of a comparatively slight fall of summer temperature would be very great. I quote from Forbes' 'Norway and its Glaciers,' p. 215:—

"Though the surface actually covered by perpetual snow in Norway be small, yet the mountainous districts and tablelands everywhere approach it so nearly that the snow-plane may be said to *hover* over the peninsula, and any cause which should lower it even a little would plunge a great part of the country under a mantle of frost."

And again, p. 243:—

"It is exceedingly probable that a diminution of the temperature of the summer months by 4° only would at once place *one-fourth* of the surface of Norway within the snow-line; and so vast a mass of snow would refrigerate the climate, especially the summer temperature, to such a degree as would unquestionably pour glaciers into the head of every fiord in western Norway. . . . The lowering of the snow-line over so large a surface would deteriorate the climate and lower the mean temperature, which would lower the snow-line still further."

The change in the eccentricity of the earth's orbit is in all probability amply sufficient to account for this or a much greater change in summer temperature.

I take the following data from Mr. Croll's paper. The recently ascertained error in the old determinations of the sun's distance affects both distances alike, and consequently does not affect their ratio. Along with the maximum distances of the sun at present and at greatest eccentricity, I state the proportionate quantities of heat the earth will receive under those two different conditions:—

	Sun's maximum distance.		Ratio of heat received.
At present	96,473,205	miles	100
At greatest eccentricity..	102,256,873	"	90

So that in the one case the earth receives about one-tenth less heat than in the other.

The sun's maximum distance occurs at present a little after the midsummer of the northern hemisphere. When it occurred at the same time of the year during the period of greatest eccentricity, the earth at our midsummer was receiving only nine-tenths of the quantity of heat which it now receives at that time of the year. I cannot calculate the effect on climate; but it must have been very great, not only directly, by depressing the snow-line, but as Forbes remarks in the place cited above, indirectly by chilling the air—and I will add, by filling the North Sea with the icebergs which must have broken off from the glaciers that filled the Norwegian fiords, as they do now from the glaciers of Greenland. We have plenty of evidence of iceberg action during the glacial period.

I believe I have shown that glaciation depends chiefly on a cold summer, but partly also on an abundant snow-fall. I have now to show that a period of cold summers, caused as I have explained, must be also one of snowy winters; so that the two conditions favorable to glaciation will occur together.

During the mild winter of the glaciated hemisphere, there is a hot summer in the opposite one. Increase of temperature promotes increase of evaporation in a much greater ratio than that of the increase of temperature; and increased evaporation in the summer hemisphere will produce increased snow-fall in the winter one. We know that at present the vapor raised in one hemisphere is to a great extent precipitated in the other; for, were it not so, the southern hemisphere, by reason of its greater extent of ocean surface, would have a rainier climate than the northern; and such does not appear to be the case on the whole. Besides, during a glacial period, the atmospheric circulation between the two hemispheres, at the time of the earth's minimum distance from the sun (which on my theory was in the winter of the glaciated hemisphere), must be more active than ever it is now; for when the earth, at either solstice, was nearer the sun than is ever the case now, and the difference of temperature between the two hemispheres consequently at its greatest possible amount, this would produce a very active circulation of atmospheric currents between the two hemispheres, which would involve the deposition as rain or snow in the winter hemisphere of a great part of the moisture evaporated in the summer one.

[The author continues with remarks on fiords as results of the Glacial era, a subject long since discussed in this Journal.]

3. *Geological Report of the exploration of the Yellowstone and Missouri Rivers;* by Dr. F. V. Hayden, Assistant under the direction of Captain (now Lieut. Col. and Brevet Brig. Gen.) W. F. Reynolds, Corps of Engineers, 1859–60, with a colored map. 174 pp. 8vo. 1869.—Several years have elapsed since the explorations for this report were made, and many of its general conclusions have appeared, through the author, in this Journal. The details here presented will be read with much interest. The

map is large and very instructive, showing, more accurately than had been done before, the distribution of the Tertiary and Cretaceous formations, and the girt of Carboniferous and Potsdam rocks around the high metamorphic ridges of the summit. Some further explorations of the mountains are required to make certain all the points in this distribution.

The last thirty pages of the volume are occupied by a report on the Cretaceous and Tertiary plants of the region, by Dr. J. S. Newberry, now Professor of Geology and Paleontology in the School of Mines, Columbia College, New York. Dr. Newberry's extensive knowledge of the fossil Botany of North America has enabled him to give his memoir great value. Dr. Hayden's absence in the mountains, during the past year, while his report was in press, accounts for its many typographical errors.

In the exploration of last year here referred to, Dr. Hayden was engaged in a new Government Survey under the direction of the Department of the Interior; and the first pages of the "Preliminary Field Report of the Survey" have been received by us. The Report promises to be one of great value to the science, and a notice of its results may be looked for in our next number. The Hon. T. D. Cox, Secretary of the Interior, states in his annual Report for the year 1869, that "Dr. Hayden entered on his labors in the field the last of June, at Cheyenne, Wyoming Territory. His route was through Denver, the silver and gold mining region of Georgetown and Central City, the Middle Park, Colorado City, and Fort Union to Santa Fé, returning through the San Luis Valley and South Park to Denver. The exploration, though brief and rapid, was eminently successful, and the collections in geology, mineralogy, botany, and zoology were extensive. His preliminary report bears date Oct. 15. It is accompanied by two other reports made to him by his assistants—one on mines and mining, the other on agriculture. These papers are a valuable contribution to our knowledge of the subjects which they embrace, and merit careful perusal."

4. *Mineralogy Illustrated;* by Dr. J. G. v. KURR, Prof. Roy. Polytechn. School at Stuttgart, etc. 22 large colored plates interleaved with explanatory text.—The figures in this Atlas represent in colors crystals or massive specimens of various minerals, especially the ornamental species, and is intended to aid the student in their identification. The figures are in general well colored; and although the text is not wholly free from its German idiom, the work may be of value in the study of the science.

5. *Tableau Mineralogique;* by M. ADAM, Commander de la Légion d'Honneur, etc. 102 pp. 4to. Paris, 1869.—A classified catalogue of the minerals in the splendid collection of Mr. Adam, of Paris, with a brief statement of the character and composition of the species.

III. BOTANY AND ZOOLOGY.

1. *Botanical Notabilia.*—Some announcements of recent publications with cursory remarks, and items of intelligence are here brought together in the expectation that they may be interesting or useful to botanical readers of the Journal. The only one of the publications here mentioned which can be said to possess much general interest is the first, viz:

An *Address of George Bentham, Esq., President of the Linnæan Society, London*, read at the Anniversary Meeting, May 24, 1869. It is the latest one of that series of pertinent annual discourses by which Mr. Bentham's presidency has been distinguished, and which it is hoped he will continue. A preceding one was reprinted in this Journal, and it would be well that this should be also. The topic is *Geographical Biology*, considered first for plants and then more succinctly for animals. Although distribution is one of the strongest points of derivative doctrine, yet it is wonderful to see, in the light of this sober and impartial survey, how entirely the whole aspect of philosophical natural history in this regard has changed within two decades. "Centres of creation," and the like are of the language of the past, here replaced by Bentham's happy term of "areas of preservation." And the conclusion, tardily reached "that the present geographical distribution of plants was in most instances a derivative one, altered from a very different former distribution," has been followed by the conviction that the present species themselves are equally derivative, and have a changeful history, some steps in which may be dimly surmised by the study of cognate forms, extant or fossil. At the point now reached, if not by general yet by large consent, the problems we are led to consider are such, that it is indispensable to have a term of wider application than "species" technically means; and Mr. Bentham here appropriates to this use the word *Race*, to denote either permanent variety (the old meaning of the word when definitely restricted), or species, or groups of two or more near and so-called representative species, i. e., for those collections of individuals or resembling groups of individuals whose association in the way of lineage is taken for granted by this class—or rather by these classes—of naturalists. As the term was only beginning to get fixity in its restricted sense, it will take the wider sense without confusion or difficulty, and with the advantage of a vernacular instead of a new-coined purely technical word.

The Miscellaneous Botanical Works of Robert Brown, which Mr. Bennett has edited for the Ray Society (2 vols. 8vo), are now completed by the Atlas of Plates, in small folio, 38 plates. The best thanks of Botanists, especially of the younger ones, are due to Mr. Bennett and to the Council of the Ray Society.

Another publication by the Ray Society for which botanists will be grateful is the *Vegetable Teratology, an Account of the principal Derivations from the usual construction of Plants*, by Dr. Masters. It was published last autumn, and forms an 8vo volume of nearly 600 pages, illustrated by over 200 wood-cuts.

The collection of cases is ample, the arrangement clear and scientific, and the general handling of morphological questions and theories of structure shows a full acquaintance with the subject. One cannot here well advert to points which invite discussion or further remark. Indeed a treatise of this character and upon such topics ought to be reviewed *in extenso*. It should be observed in passing that it may not be quite correct to speak of DeCandolle as "giving in his adhesion to the morphological hypothesis of Goethe (p. xxii, also p. 476): it is generally understood that when the *Théorie Elémentaire* and the *Organographie* were written DeCandolle knew nothing of Goethe's essay, and had never heard of Wolff.

A memoir of the Life of the late Prof. Wm. H. Harvey, principally made up of his own inimitable letters, edited by a surviving relative, has lately been published by Bell and Dalby, London. The book was at first intended for private distribution; but it was well decided, as his many friends and admirers in this country will be glad to know, that it should be issued through a publisher in the usual way. It makes an octavo volume of goodly size. Such a charming photograph of a lovely character will interest many to whom Dr. Harvey was personally unknown.

The *Genera of South African Plants* was one of the late Dr. Harvey's first undertakings when established, it was thought for some years, at the Cape of Good Hope. It was published at Cape Town, in 1838, and most useful it was in inspiring and developing the study of Botany in the Colony: nor is its usefulness superseded by the elaborate *Flora Capensis*, which was carried on with remarkable promptitude while Dr. Harvey lived, but which remains unfinished. He had prepared in a good degree the materials for a new edition of the *Genera*, which has now been edited by Dr. Hooker, the succinct introduction to Botany originally prepared by Mr. Bentham for his British Flora, and since added to all the Colonial Floras, being prefixed.

As to these Colonial Floras, that of Australia is pushed forward with Mr. Bentham's customary vigor, under the great advantage of his unsurpassed knowledge and his enviable opportunity of being able to devote his whole time without distraction to Systematic Botany. The fourth volume of the *Flora Australiensis* appeared almost a year ago: it contains most of the Monopetalous orders after the *Compositæ*, excepting *Verbenaceæ*, *Labiatæ*, &c., which are probably already in type for the fifth volume. Under *Breweria* Mr. Bentham justly remarks that this genus ought not to have been referred to *Bonamia* of Madagascar, as I had rashly done; yet he is wrong in the supposition that Thouars' plant not Convolvulaceous, but allied to *Ehretia* and *Cordia*. On inspection it proves to differ from *Breweria*, and to agree with *Cressa*, in the corolla, which not plaited in æstivation. There are probably two species.

The *Flora of Tropical Africa* by Prof. Oliver, "assisted by other botanists," though not exactly a Colonial Flora, is upon the same model. It is founded upon the African collections which have accumulated at Kew. Considerable as they are already, they represent the vegetation only of the outskirts of a vast *terra incognita*, of which we may hope to know something ere long, and which may give to this work as it advances an exceeding interest. This first volume, which was published in 1868, includes the orders antecedent to *Leguminosæ*. The *Malvaceæ* and their allies are by Dr. Masters, who has paid much attention to the structure of the flowers of this group; the *Ampelideæ*, *Sapindaceæ* and *Connaraceæ* are by Mr. Baker.

Dr. Oliver has just published a neat little *First Book of Indian Botany*, on the basis of his well-known elementary *Lessons* for home use, only the illustrations of the natural orders, the examples, &c., are from Indian plants, and considered in view of Indian Botany.

The ninth part of Dr. Seemann's *Flora Vitiensis*, nearly concluding the *Phanerogamia*, has been for some time issued; and the 10th, which will complete this laborious work, is in press. The Ferns are by Dr. Caruthers of the British Museum, so favorably known for his researches in fossil botany.

Mr. Baker, the Assistant Curater of the Kew Herbarium, after completing the *Synopsis Filicum* which was barely commenced by Sir Wm. Hooker, has made the results of that work the basis of a very interesting paper *On the Geographical Distribution of Ferns*, in the last (26th) volume of the Transactions of the Linnæan Society.

The publication of Sir Wm. Hooker's *Icones Plantarum* closed a dozen years ago with the 10th volume, completing a thousand plates. Dr. Hooker with the assistance of Mr. Bentham and Prof. Oliver, has now commenced a third series, of which two parts are issued, one in November, 1867, the other in June, 1868, and a third part is in press. The plates are numbered on from volume 10 (which is a convenience in citation) viz: 1001 to 1050. They are taken from plants in the Kew Herbarium, and will serve to illustrate some of the work going on in that richest of botanical collections, and notably, as it proceeds, the *Genera Plantarum*. Thus far nearly all are from the southern hemisphere. Two plants, however, are North American, viz: *Arceuthobium brachypodum* of Engelmann, from New Mexico, in which Prof. Oliver directs attention to some apparent peculiarity of the ovule, which needs investigation in the fresh plant; and *Leitneria Floridana* of Chapman, which Prof. Oliver describes as having a thin but evident layer of albumen around the embryo, and he agrees with Chapman in referring the genus to *Myricaceæ*, although with misgivings.

A whole volume of the *Journal of the Linnæan Society* (the twelfth, issued in advance of the eleventh), is occupied with an enumeration and description of all known Mosses of South America, by Mr. Mitten, founded primarily on Spruce's collections, which have been distributed into sets and disposed of. Mitten's *Musci Austro-Americani* thus forms a substantial 8vo volume of 659 pages. A double number of the eleventh volume is equally devoted to Mr. Spruce's South American collections and researches, viz., to the *Palmæ Amazonicæ*, an account by himself of the

Palms of the regions visited by him, a paper rich in generally interesting and readable as well as technical scientific matter.

Dr. Anderson has a paper on the Palms of Sikkin in the preceding number of the same volume; Dr. Kirk writes on the Copal of Zanzibar, and makes out that the old or fossil copal is the produce of the same tree, a species of *Trachylobium* from which recent Zanzibar copal is at present yielded. The other articles most noteworthy for us in the eleventh and the later numbers of the tenth volumes, are one by A. W. Bennett of London on *the Structure and Affinities of Parnassia*, upon which there is somewhat to be said whenever the present writer has opportunity to make re-examinations in the view of correcting certain probable mistakes or oversight. *On chemical reaction as a specific character in Lichens*, by Dr. Lauder Lindsay, who comes to the conclusion that these chemical tests introduced of late are of little value or reliability. *Notes on Jussiæa* by Charles Wright, a letter to Dr. Hooker, showing what excellent characters, hitherto nearly overlooked or in some cases misapprehended, are furnished by the seeds, &c., in this genus: and finally *Fungi Cubenses*, by Messrs. Berkeley and Curtis, founded on the very ample and largely novel collections in this order made by Mr. Charles Wright. It is to be stated here that these Fungi, accurately determined by the above distingnished mycologists, have now been distributed into sets, and placed on sale. Application for the few remaining sets may be made by letter to Mr. Wright, at the Harvard University Herbarium, Cambridge, Mass.

General Munro, who, when stationed in Canada, did much for American Agrostology, and now in England is able to command time for systematic work in his favorite order, has published in the Transactions of the Linnæan Society, a Monograph of *Bambusaceæ*. These, as now known, amount to upward of 170 species, belonging to 20 genera, our Cane of the Southern States being the solitary representative of the tribe in this country. The rare flowering which renders the study of the group difficult, is a common, though not universal feature. The common Bamboo of India is thought to blossom in any district only once in thirty or forty years, and when a general flowering occurs, the copious seed, giving sustenance to thousands, has often averted a famine.

For a French edition of his little work on the Fertilization of Orchids by insects, Mr. Darwin had occasion to prepare an appendix, enumerating the principal contributions to our knowledge of this subject, which have been made since this volume called attention to it and made the enquiry popular. There being as yet no call for a new edition in England, this appendix, of a few pages in extent, was turned into English and printed last summer in the Annals and Magazine of Natural History.

Dr. Baillon, now the Professor of Botany in the School of Medicine, Paris, commenced the publication of the "*Adansonia, Receuil Periodique d' Observations Botanique*" (8vo,) in 1860, and the 8th volume was completed in the summer of 1868. Each volume is illustrated by ten or twelve plates.

A large portion of the articles are by the able and indefatigable editor, the first being his essay on the female flower of *Coniferæ*, and against gymnospermy, which at the time attracted much attention. (Apropos to which, it is said that the doctrine of *gymnospermia* was first propounded by Targioni Tozetti. I have not seen the passage in which it is said to be recorded.) A second article describes, earlier than elsewhere, the setiform bodies which stand in place of petals in *Asarum Europæum*; but states that they are wanting or generally so in *A. Canadense;* they are, however, very commonly present. In the seventh and eighth volumes are brought together a very interesting collection of Trécul's various papers on the latex, in which he shows that this juice is contained in the spiral, dotted, and other ducts as well as in the so-called vessels of the latex.

Prof. Baillon commenced in 1868, a work on Organogeny, like that of Payer's, of which it would be a sort of supplement, but extending to the fruit as well as the flower. Only a single fasciculus has yet appeared of this *Traité du Developement de la Fleur et du Fruit*, (V. Masson et fils), with one plate, devoted to the flower of *Santalaceæ.* A more generally interesting work of the same author, and one which is pushed forward with vigor, is his *Histoire des Plantes* (imperial 8vo. Hachette & Cie, Paris), in a series of monographs of families, with wood-cut illustrations, the text with full readable details in French, with copious references, and then full generic characters in Latin. The three parts already published (1868–1869), comprise the *Ranunculaceæ*, the *Rosaceæ*, the *Connaraceæ* and the *Leguminosæ-Mimoseæ.* To give an idea of Baillon's valuation of genera, and how greatly he would reduce them, it may be noted that he refers back both *Eranthis* and *Coptis* to *Helleborus*, joins *Caltha* as well as *Calathodes* to *Trollius*, *Aconitum* to *Delphinium*, *Trautvetteria* to *Ranunculus*, and *Cimicifuga*, to *Actæa;* moreover, he refers the latter genus along with *Thalictrum* to the *Clematideæ.* *Crossosoma* he doubtfully places by the side of *Pæonia*, which appears to be the best that can be done with it, giving weight rather to the perigynous petals and stamens than to the arillus. He calls attention to his discovery, first recorded in the Adansonia, of three or four additional but minute and early abortive ovules in *Anemone* and *Clematis.* In *Rosaceæ*, beyond the reductions made by Bentham and Hooker, *Chamærhodos* also is united with *Potentilla*, and *Waldsteinia* as well as *Coluria* with *Geum;* Torrey's *Coleogyne* is well placed next to *Cercocarpus* and *Purshia;* but Baillon is much mistaken in supposing that he was the first to refer *Lutkea* or *Eriogynia* to *Spiræa*; it was so referred in the Flora of N. America more than a quarter of a century ago. In Torrey's *Emplectocladus* Baillon has rightly detected a *Prunus*, not far removed from Humboldt's *Amygdalus microphylla.*

It is rather late to notice Burean's *Monographie des Bignoniacees* (Baillière, 4to) of which the two parts issued bear the date of 1864, but the work is hardly known in the country and has not advanced far. The 200 or thereabouts pages of letter-press are given to a prolix account of the history of the classification of the order, its affinities, organography, &c. The thirty-one plates appear to be excellent. There is a figure of our *Bignonia capreolata* L., under the name of *Anisostichus capreolata*, of *Tecoma stans* as *Stenolobium stans* Seem., of *T. radicans* as a *Campsis* (in the letter-press), and of *Catalpa bignonioides*.

The other section of the 16th volume of *DeCandolle's Prodromus* has just been issued. The two parts form indeed independent volumes, and are paged and indexed as such, so that for all time botanists will have to quote *DC.* Prodr. 16 (1), p., &c., which is to be regretted, but there is no help for it. The present (prior) part, of 450 pages besides 65 intercalated ones, contains the *Buxaceæ* and some other plants excluded from the *Euphorbiaceæ*, by Dr. Müller; the *Empetraceæ* by Alph. DeCandolle himself (*Empetrum* reduced to one species, *Corema* of two, and a *Ceratiola*); *Cannabineæ* by the same (the *Ulmaceæ* and *Artocarpeæ* postponed not being ready), the *Urticaceæ* (i. e. the *Urticeæ*) by Weddell; *Piperaceæ* by Casimir DeCandolle (the *Saurureæ* made a mere tribe, and the *Pipereæ* mainly included under Piper of 635 species, *Peperomia* of 389!); *Chloranthaceæ* by Solms-Laubach of Halle, reduced to three genera; and finally *Garryaceæ* by the editor, comprising nine species of *Garrya*. It appears that the latter end of the volume was printed first, which explains the omission of *G. buxifolia*, a species discovered in Northern California by Bolander, and published a year and a half ago. If one ort wo collaborators will now bring up their arrears, the editor may very soon have the great satisfaction of announcing the completion of the great Dicotyledonous series.

The incomparable *Flora Danica* goes on, and the 47th part, with plates 2701 to 2760, has come to hand. Among the plants of interest to us which it contains is *Pyrus* (*Sorbus*) *Americana*, our Mountain Ash, with the red petioles and pointed leaflets, from Greenland.

In the Journal of the Natural History Society of Copenhagen (Vidensk. Middel. Naturhist. Forening Kjobenhavn) for the year 1866, issued in 1867–8, Oersted has an elaborate paper on the classification of Oaks, with a catalogue of all the species, and many illustrations, both copper plates (of female flowers) and woodcuts; of the latter, the cuts from impressions of the leaves, showing the venation, are peculiarly excellent. Being a later version of *Quercus* than that of DeCandolle, and with points of its own, it is commended to the attention of Dr. Engelmann, who is likely to have most to do with the American species. To illustrate venation and the nature of the surface of foliage, photography may be turned to good account, far more than is now commonly thought of. We have seen a photograph from a specimen of one of the coriaceous-leaved Oaks of the Dutch Indies which was truly wonderful in its rendering.

Dr. Lange, in the same publication for 1867 (issued in 1868), describes the *Pyroleæ* and *Monotropeæ* of Mexico and Central America. Four of the former group are identified with United

States species; and the fifth, *Pyrola Liebmanni* of Lange may be added, as it is apparently undistinguishable from one of our Western forms which already has several names, among them *P. bracteata*. Zuccarini's *Monotropa coccinea* is described in full and beautifully figured. The lively red color, in which it chiefly differs from *M. uniflora*, may not be of specific importance, considering that what we take for *M. Hypopitys* in the United States is often flesh-color or red in the warmer parts of the country.

A far more interesting Monotropeous plant has been collected by the French expedition to Mexico, viz: *Pleuricospora* Gray, (in Proceed. Am. Acad. 1867), with mature fruit, well showing the parietal placentation, and the close-coated seeds.

Prof. Bunge of Dorpat has brought out the first part of his Monograph of the *Astragali* of the Old World. It forms a fasciculus of 140 pages, in the current volume (11 of the 7th series) of the Memoirs of the St. Petersburg Academy of Sciences (1868), and contains the *Claves Diagnosticæ* of all the species, under their subgenera and sections. We have a goodly number of species in this country, mainly beyond the Mississippi; there are about 200 known in America,—a small matter compared with those of the Old World, of which Bunge here characterizes a little short of a thousand species! It is a subject of congratulation that, thanks to the author's great carefulness and knowledge there is hardly any double employment of specific names for *gerontogæan* and *neogæan* species. It would have been better to have avoided the use of names for sections in the same form as those of genera by adopting a plural termination or some like device.

A remarkable parasitic plant of the Sonora desert, indicated in 1854 in *Plantæ Thurberianæ*, but fully published and illustrated as much as ten years later by Dr. Torrey in the *Annals of the New York Lyceum*, his *Ammobroma Sonoræ*, has recently been investigated, along with its allies, by Count Solms-Laubach, a young botanist of high promise, now resident at Halle. It was thought that the incomplete specimen brought by Col. Gray and now belonging to Dr. Torrey was the only one extant. But it appears that much better ones were gathered by C. Schukard, draughtsman of the party, and sent along with a drawing, to Dr. Behr of San Francisco, who presented them to the late Prof. Schlechtendal of Halle. Solms-Laubach, a former pupil of Schlechtendal, found the specimens in his herbarium, also good ones of *Lennoa madreporoides*, and having likewise examined Kunth's *Corallophyllum cæruleum*, had thus before him all the known representatives of the group except Nuttall's *Pholisma*, which is known in Europe only by the specimen in the Hookerian Herbarium which served as the original of the figure in the *Icones Plantarum*, and probably by one in Nuttall's own herbarium now belonging to the British Museum. The results are just published in an elaborate memoir: "*Die Familie der Lennoaceen, von Hermann Grafen zu Solms-Laubach*," a separate issue from the eleventh volume of the Transactions of the Natural History Society of Halle, bearing the date of 1870. The three plates illustrate in detail the three plants examined, viz: *Ammobroma Sonoræ* Torr., *Lennoa madreporoides* Llav. & Lex., and *L. cærulea* Solms, which is Kunth's *Corallophyllum cæruleum.* The order *Lennoaceæ* of Torrey is divided into two sections, 1st, with stamens in one rank and the anther-cells parallel for *Pholisma* and *Ammobroma*, each of a single species; 2nd with the alternate stamens inserted lower than the rest, and the anther-cells contiguous at the apex but diverging below, for *Lennoa*, of two species. Solms doubts, and with good reason, whether *Ammobroma* should not be referred to *Pholisma*, which would leave two very well defined genera. The difference in the ovule, whether horizontal or perpendicular becomes of small consequence when it is seen that the rhaphe in the former case is on the lower side, indicating a pendulous ovule. By several pertinent considerations Solms reinforces Dr. Torrey's opinion that the affinities of these plants are with the Erical alliance and not at all with the *Orobancheæ;* but the insertion of the stamens, even more than the structure of the ovary and fruit, forbids union with the *Monotropeæ.* That character belongs, however, to a great part of *Epacrideæ*, and Solms shows us that the structure of the ovary is the same as in some of the latter, and in certain *Vaccineæ.* The cells, as he shows, are half carpels, each carpel being biovulate and divided into two uniovulate *locelli* by intrusion from the back, as in *Gaylussacia.*

Professor Braun, continuing his study of the *Rhizocarpeæ* and the like, published last year a little monograph of the Australian species of *Isoetes*, with a preface containing general remarks on those of Europe and North America. He has also published more extensively upon *Characeæ;* and Dr. Leonhardi, the Professor of Philosophy in the University of Prague has discussed the European species in detail in the Proceedings of the Natural History Society of Brunn, and in the *Lotos.* We have from Dr. Hegelmaier a second dissertation on *Callitriche*, aided as to the American species by Dr. Engelmann, who placed the notes and specimens of his herbarium at his disposal. He recognizes *C. marginata* Torr., in Bolander's collection; *C. microcarpa*, a new species of Engelmann from Wright's Cuban collection; *C. Japonica* of the same, collected by Wright in Japan; and describes a new California species, *C. Bolanderi.* Hegelmaier has published his Monograph of *Lemnaceæ*, in 4to, but we have not yet seen it.

Prof. Miquel has carried on the *Annales* of the Leyden herbarium as far as to the fifth fascicle of the fourth volume; the papers in the current volume thus far relate almost wholly to the botany of the Indian Archipelago.

The seventh volume of Walpers' *Annales Bot. Systematicæ*, continued by Dr. C. Müller, gets on but slowly: the first and second fascicles bear the date of 1868, and we have only the third for 1869, which comes down only to the *Zygophylleæ.*

Dr. Pritzel's *Iconum Botanicarum Index Locupletissimus*, a perfect model for typography and arrangement as well as careful editing, was supplemented in 1866 by a *pars altera*, of nearly 300 pages, bringing down the references to plates to the end of the year 1865. The first edition of the main work has been reprinted verbatim, along with this supplement, instead of redigesting the whole, which would have been preferable. But it will temporarily do very well as it is, if the editor will soon re-edit the whole, incorporating into one alphabetical order the plates published down to 1870.

In the summer of 1868 appeared the 44th, 45th and 46th fascicles of Martius' *Flora Brasiliensis*, comprising the *Loranthaceæ*, a masterly work by Dr. Eichler; the *Oleaceæ* and *Jasmineæ* by the same (the character of *Chionantheæ* "semina exalbuminosa" still kept up, though it is not so either in *Chionanthus Virginica* itself or in the original *Linociera ligustrina;* see Proceed. Amer. Acad., 5, p. 331, etc.); the *Loganiaceæ* by Progel, and the *Styraceæ* by Seubert. Since the lamented death of Von Martius, Dr. Eichler has brought out the *Balanophoreæ* (in fasc. 47), with an admirable investigation and illustration of the intimate structure or anatomy as well as of the floral characters and morphology of this family, and has clearly shown it to have the ovulation of *Santalaceæ* and *Loranthaceæ* (some of them very exactly of the former), and to belong to that alliance.

The 48th part, the *Convolvulaceæ* by Meissner, has just been issued, but has not yet come to hand. Before his death, Von Martius had fortunately completed such arrangements with the Brazilian Government on the one hand and with Dr. Eichler on the other, as to secure the continuance and completion of this great work, that is, if it can be done within ten years; and Dr. Eichler is pushing it forward vigorously. He is placed at disadvantage, however, by the seemingly ill-advised refusal of the Bavarian Government to purchase and retain in Munich the library and herbarium of the *savant* who has done far more than any one else for natural science in Bavaria; and so the library of Martius is to be dispersed by auction next March; and the herbarium, which his will forbids the dispersion of, still awaits a purchaser. A pamphlet, *Das Herbarium Martii*, gives particulars of the contents of this collection. It comprises, 1, the general herbarium, estimated to contain about 60,000 species in 300,000 specimens, over half the species South American, especially Brazilian; 2, The Palm collection, which ought to be of very great importance; 3, A collection of fruits and seeds; 4, of woods; 5, a very rich and well-prepared collection of drugs and economical products, the larger part of which was formed by his brother Theodore Martius, when Professor of Pharmacy at Erlangen. Here is an unusual opportunity for some American University.

We have received a second edition (1864) of an *Atlas des Pflanzengeographie*, by L. Rudolph of Berlin, (published by Nicolas),* intended for schools, &c. It is well done, and if in English would answer an excellent purpose in our higher schools, or wherever Botany and Physical Geography are taught. It is strictly an Atlas, of nine folio plates or maps, charged with details, which

* Received from E. Steiger, German bookseller, Frankfort St. New York, along with a copy of Pritzel's Index (mentioned on the preceding page.)

are printed partly in colors, and with descriptive letter-press on the reverse. The centennial anniversary of the founder of Plant-geography should awake new interest, and give increased popularity to the subject.

The new President of the ancient Imperial Academy Naturæ Curiosorum, succeeding Carus, is Professor Behn of Hamburgh.

An interesting bit of botanical literature, is Pursh's *Journal of a Botanical Excursion in the Northeastern parts of Pennsylvania and New York, during the year* 1807. Dr. Thomas P. James found the manuscript journal of Pursh with some other papers accompanying the herbarium of Dr. B. S. Barton, in the possession of the American Philosophical Society, and had it printed in successive numbers of Meehan's *Gardener's Monthly*, from which it is now collected in the form of a little volume of eighty-seven pages. It will be remembered that this journal contains Pursh's notes made at the time of his discovery of *Scolopendrium*, and the station is indicated with sufficient precision to be determined, as was done, we believe, by Mr. Paine. If the Fern no longer exists at that very station, we know of it at three or four neighboring localities. Pursh's quaint and simple narrative of his wanderings and hardships is well worth perusal.

The Botanical Necrology for the year 1869, may happily be dismissed in few words.

Antonio Bertoloni, the most venerable botanist of our day, who has occupied the chair of botany in the ancient university of Bologna for considerably more than half a century, died, in the full possession of his mental powers, on the 17th of April, shortly after the completion of his ninety-fourth year. The very next day died the equally distinguished professor of the sister University of Turin, *Giuseppe Moris*, in the seventy-third year of his age. At Prague on the 28th of July, died the professor of Physiology, *J. E. Purkinje*, at the age of eighty-two. He was known in botany as the author of a neat little treatise, "*De cellulis antherarum fibrosis*," etc. A. G.

2. *Recent Explorations of the Deep-sea Faunæ;* by A. E. VERRILL,—A new era in the history of marine zoölogy may be said to have commenced in 1860, when Dr. Wallich obtained a number of Worms, Crustacea, Bryozoa, and Echinoderms at depths varying from 445 to 1913 fathoms, and from these observations inferred that the deep-sea had its own peculiar fauna, at depths far greater than life had previously been supposed to exist, unless in the lowest forms, such as the Rhizopods obtained from soundings and described by Bailey and others. This inference was at once confirmed by the observation of A. Milne-Edwards, who in 1861 reported a number of living mollusca and corals, found adhering to the telegraph cable between Algiers and Sardinia, when taken up for repairs, on portions that had been sunk to depths of 1093 to 1577 fathoms. Some of these were new, others were known only as Tertiary fossils. In the same year the Swedish

expedition to Spitzbergen obtained Tunicates, a Zoöphyte, a Crustacean, and a bivalve-shell from 1400 fathoms. Later, G. O. Sars has made extensive explorations by means of the dredge at the Lofoden Islands, and on the Scandinavian coast in depths of 200 to 300 fathoms, and in some cases down to 450 fathoms. Prof. Sars reports,* as the result of his son's explorations, 427 species of animals living between 200 and 450 fathoms, and representing most of the marine classes: Rhizopods 68; Sponges 5; Polyps 20; Hydroids 2; Crinoids 2; Ophiurians 14; Asterians 7; Echinoids 5; Holothurians 8; Gephyrea 6; Annelids 51; Crustacea 106; Polyzoa 35; Tunicates 4; Brachiopods 4; Conchifers 37; Gasteropods 53. He also records 9 fishes living at those depths. Of the whole number 42 were found at 450 fathoms, and 46 were confined to the region below 200 fathoms, while most of the others extend upwards to quite shallow waters. Among the many remarkable new forms the *Rhizocrinus Lofotensis* Sars is especially notable, and has been the subject of an admirable memoir by Prof. Sars.† It is remarkable as giving us a new living type of attached Crinoidea, belonging to a family most characteristic of the Jurassic formations, and is of especial interest in this connection, as it has also been found since at several other very remote localities, even as far south as Florida, at similar depths. In 1867 the Superintendent of the U. S. Coast Survey undertook an extensive exploration of the Gulf Stream, which has already yielded most important results in deep-sea zoölogy. The dredging, under the charge of L. F. de Pourtales has been carried on during three past seasons, between Florida and Cuba, from the shallow waters of the shore to the deepest waters of the mid-channel, which seldom exceeds 550 fathoms, the dredgings not having gone beyond 700 fathoms. From these explorations large and most remarkable collections have been obtained, embracing numerous representatives of nearly all classes of marine animals. A part of these have been described in the Bulletin of the Museum of Comparative Zoölogy,‡ but the Crustacea, Worms,

* Videnskabs Selskabs, Förhandlingar, 1867, pp. 246 to 275; and Annals and Magazine Nat. History, vol. 3, p. 423, June, 1869.

† See this Journal, xlviii, p. 142.

‡ No. 6.—*Contributions to the Fauna of the Gulf Stream at great depths.* By L. F. DE POURTALES, Assistant U. S. Coast Survey, December, 1867. Contains descriptions of Worms, Polyzoa, Brachiopods, Halcyonoids, Corals, Hydroids, and Crinoids

No. 7.—Same title, Dec., 1868. Contains general account of dredgings, with descriptions of Brachiopods, Crinoids, Holothurians, Corals.

No. 9.—*Preliminary Report on the Echini and Star-fishes dredged in deep water between Cuba and the Florida Reef*, by L F. DE POURTALES; *prepared by* ALEXANDER AGASSIZ, October, 1869. Contains descriptions and tables of distribution of the Echini; descriptions of the young of Echini and their development; and a list of the star-fishes.

No. 10.—*Preliminary Report on the Ophiuridæ and Astrophytidæ dredged in deep water between Cuba and the Florida Reef*, by L. F. DE POURTALES; *prepared by* THEODORE LYMAN, November, 1869. Contains: I, General remarks and tables of distribution; II, Descriptions of new genera and species, with Critical Remarks.

part of the corals, and most of the Mollusca are still undescribed. Enough has been done, however, to reveal a wonderfully rich fauna and make us look for still greater discoveries in the future.

Another exploration,* which has yielded some of the most important results, was undertaken in 1868, by Dr. W. B. Carpenter and Dr. Wyville Thomson to explore the region between Scotland and the Faroe Islands. They were furnished with a Government vessel, fitted for the purpose, but owing to very bad weather could use the dredge only nine days during the cruise of six weeks. They obtained, however, quite a variety of animals at from 400 to 650 fathoms, including the *Rhizocrinus Lofotensis* and a remarkable variety of vitreous sponges, which seem to be very characteristic of the deep-sea fauna. But their observations upon the temperature at great depths are of the greatest importance. An extensive area was discovered between the Faroe and Orkney Islands, where the minimum temperature in 450 to 550 fathoms was from 32° to 33¾°. This region was characterized by an arctic assemblage of animals and a sandy and stony bottom. South and west from this "cold area," and extending far to the west of the Faroe Islands, was a warm area where the minimum temperature at 450 to 650 fathoms was 46° to 49°, the surface temperature being 52° to 54½°, while over the "cold area" the surface temperature was nearly the same, 50° to 52°. The warm area was characterized by a bottom of soft mud, composed chiefly of the shells of *Globigerinæ*, "*coccoliths*," "*coccospheres*" and other forms of Protozoa. Living upon this bottom were various vitreous sponges, allied to *Hyalonema*, and living like it with their long, slender siliceous spicules buried in the mud like rootlets, and several *Annelids*, *Rhizocrinus*, *Kophobelemnon*, *Terebratula*, *Lophohelia prolifera*, etc. The character of the bottom and its fauna strikingly recalled the chalk of the Cretaceous period, and the authors of these discoveries claim that *the* chalk formation has been continuous since the Cretaceous, and is *still forming* in the depths of the Atlantic. Another expedition was undertaken during the past season by the same parties, but we have seen no statement of the results, except that *Buccinum undatum* was dredged living in

No. 11.—*List of the Crinoids obtained on the coasts of Florida and Cuba, by the United States Coast Survey Gulf Stream Expeditions, in* 1867, 1868, 1869. By L. F. de Pourtales. Contains descriptions of eight species of Crinoids (six of *Antedon*), with a table showing their distribution.

No. 12.—*List of Holothuridæ from the Deep-sea dredgings of the U. S. Coast Survey.* By L. F. de Pourtales. Contains six species, three of which (*Echinocucumis typica*, *Cucumaria frondosa*, *Molpadia borealis*) are referred to north European species, and two others are regarded as possibly identical.

No. 13.—*Report upon Deep-sea Dredgings in the Gulf Stream, during the Third Cruise of the U. S. Steamer Bibb, addressed to* Professor Benjamin Peirce, Superintendent U. S. Coast Survey, by Louis Agassiz, November, 1869. Contains a general account of the work done and its results, together with an account of the rock formations now being deposited in that region, also observations on the young stages and mode of growth of several genera of corals, etc.

* Proceedings of the Royal Society, vol. xvii, p. 168, December, 1868; and Annals and Mag. Natural History, vol. 4, p. 112, August, 1869.

1,300 fathoms,* Dr. E. Perceval Wright also made an exploration 30 miles off Setuval, Portugal, in search of *Hyalonema*, which he dredged in 450 fathoms, and first ascertained its true mode of life.† From the same region he and Dr. Gray have described three species of Halcyonoid corals. By the same expedition a shark and a small fish were caught at the same depth. The recent Swedish expedition to Spitzbergen also made important discoveries, of which we have not yet seen full reports.‡ Dr. Smitt and Mr. Ljungman on the cruise of the Swedish frigate "Josephine," which visited the United States last summer, dredged some interesting animals on the newly discovered "Josephine Bank," between Lisbon and the Azores, in 117 fathoms; among them are *Ophiomyces frutectosus* Lyman, *Pteraster militaris*, *Rhizocrinus Lofotensis* Sars, and *Echinocucumis typica* Sars, all of which have been found also off Florida by Pourtales.§

These discoveries have very important bearings upon Geological science and Physical Geography, as well as Zoölogy, and will cause important changes in many generally accepted theories. The following are some of the results already made out:

1. It is certain that animal life does not begin to diminish sensibly at 100 fathoms and nearly disappear at 300 fathoms, as supposed by Forbes and generally believed previous to these late investigations. It is equally certain that the greatest depths yet reached with the dredge have an abundant and diversified fauna, with representatives of most classes of marine animals. The deep-sea animals are in part new and peculiar to great depths; in part found also in shallower waters; in part previously known as Tertiary or Cretaceous fossils.

2. It follows that abundance of fossils in a geological formation is not, of itself, evidence of shallow-water origin.

3. It is certain that *bright colored* animals are fouud at the greatest depths yet explored, and although uniform red and white are the most common colors among deep-sea animals, yet examples of nearly all the other colors have been observed, among Protozoa, Radiata, Mollusca, and Articulates,‖ as in fact we might have an-

* American Naturalist, vol. 3, p. 383, Sept., 1869. Since this article has been put in type I have had the pleasure of reading the preliminary reports of this most important expedition, by Mr. J. Gwyn Jeffreys, in "Nature," pages 135 and 166, Dec., 1869. The explorations on the Atlantic coast of Ireland by Mr. Jeffreys, extended down to the depth of 1476 fathoms, revealing a diversified fauna of an arctic character at all depths. Prof. W. Thomson conducted the explorations in the northern part of the Bay of Biscay, where the dredgings reached 2435 fathoms, with excellent results. Dr. Carpenter took charge of the additional explorations north of Scotland. The results of this expedition are of great interest and the new discoveries very numerous. It added 117 species of mollusca to the 451 previously regarded as belonging to the British fauna. Of these 56 are new to science. The mollusca obtained in 2435 fathoms are *Pecten fenestratus* (Mediterranean), *Dacrydium vitreum* (Arctic), *Scrobicularia nitida* (Finmark to Sicily), *Neæra* (new), *Dentalium* (new).

† Annals and Magazine of Nat. Hist., Oct., 1868.

‡ The Swedish expedition of 1868 obtained in soundings a *Cuma* and a fragment of *Astarte* from 2600 fathoms.

§ Bulletin Mus. Comp. Zoöl., pp. 347 and 357.

‖ See the remarks of Prof. Sars on this subject in the work quoted above.

ticipated from the fact that many burrowing annelids, crustacea, and shells, which are rarely if ever exposed to the light, are brilliantly colored.

Therefore the presence of color-markings on fossil shells is not an evidence of their shallow-water origin, as believed by Forbes and others. The finely colored specimens of *Voluta Junonia*, dredged living by Pourtales in 350 fathoms, are a sufficient refutation of this theory.

4. Prof. Sars mentions several species of deep-sea Crustacea having perfectly developed eyes, showing that light penetrates to far greater depths than is commonly supposed.* But the decrease of sea-weeds and their almost complete disappearance at about 100 fathoms may perhaps be due to the diminution or modification of the light.

5. The generally received theory that the temperature of the water at great depths is everywhere the same, in all latitudes, viz: that at which sea-water has its greatest density, formerly said by Herschel and others to be 39°, but more recently shown to be that of the freezing point of sea-water (25°·4 to 27°·4 Fahr.), is not true, at least for depths down to 700 fathoms, as shown by the observations of Thomson and Carpenter.

6. The same observers have satisfactorily shown that temperature is the main agent in determining the distribution of deep-sea animals, which had been previously shown to be the case among shallow-water forms, and that mere *depth* or *pressure* has little or no influence directly. But the chemical composition of the water (as the amount of oxygen) and the character of the bottom doubtless have their influence.

7. The last observation is connected with the discovery of two contiguous, but distinct, deep-sea faunæ, living side by side at similar depths (400 to 600 fathoms); one eminently arctic in character, occupying the "cold area" on a sandy and stony bottom; the other similiar to that of the region between Florida and Cuba, and occupying the "warm area," with a bottom of calcareous infusorial mud. The last fauna, or at least some of its species, extends over a region of vast extent, both in latitude and longitude, some of the species ranging from Florida to within the Arctic Circle, and on both sides of the Atlantic.

8. The discovery of species, genera, families, and even sub-orders, supposed to have become extinct, leads us to expect that other lost forms may still have living representatives in the vast unexplored regions of the ocean.† Among the remarkable discoveries, may be mentioned the *Rhizocrinus*; the *Haplophyllia paradoxa* Pourt., a living representative of the "Rugosa" group of corals, supposed

* Other remarkable instances are mentioned by Jeffreys: as *Lacuna tenella* and a stalk-eyed crab from 808 fathoms; *Trochus minutissimus* Mighels and *Ampelisca* from 1230 fathoms; a stalk-eyed crustacean from 1476 fathoms; a large new *Fusus* from 1207 fathoms; a *Pleurotoma* from 2090 fathoms; and *Octopus cocco* from 632 fathoms, all of which are said to have well developed eyes.

† The Porcupine expedition obtained a number of species of shells previously known only from the Tertiary (Coralline Crag and Red Crag).

not to have lived since the Carboniferous period; various new forms of sea-urchins, described by A. Agassiz, having their nearest allies in the Cretaceous, etc. The discovery of the living Cystidean noticed in the last number of this Journal is another fact of the same kind, and so remarkable that it may not seem unreasonable to anticipate hereafter the discovery of living Ammonites and Trilobites.

9. These investigations have thrown great light upon the mode of deposition of certain geological formations, especially the chalk, and at the same time illustrate the manner in which, under the influence of currents of different temperatures, a chalk and a sandstone, with entirely distinct faunæ, may be deposited side by side at the same depth and, supposing the currents to be modified, how the two might alternate, thus accounting for the extinction of faunæ and the re-appearance of "colonies," as noticed by Barrande.

10. Dr. Carpenter and Thomson claim that the chalk formation now depositing in the deep Atlantic is a direct continuation of *the chalk* formation of the Cretaceous period, some of the living species being regarded as identical with Cretaceous fossils, while others, closely allied to fossil forms, are supposed to have been modified during the lapse of time by "natural selection," or in some other way.

3. *Catalogue of the Mammals of Massachusetts; with a Critical Revision of the Species;* by J. A. Allen. Bulletin of the Museum of Comp. Zoölogy, No. 8. Cambridge, October, 1869.—This includes not only a list of the species, with their principal synonyms, but also valuable information concerning their distribution, and their relations with the species of the old world. Mr. Allen admits much greater variations in the species of mammals than most modern writers, and shows that this variation is often as great in specimens from different parts of North America as between specimens from the two continents. Consequently he has regarded many of our mammals as identical with those of Europe and Asia. Among these are the black bear, common wolf, red fox, two weasels, mink, sable, beaver, moose, and reindeer. In some cases, however, he has probably gone altogether too far in uniting species; as in considering the black-bear, the grizzly-bear, the barren ground bear, and the European bear all one species; and in his treatment of the genus *Blarina.* He has also overlooked a specimen of *Neasorex palustris* in the Museum, from Norway, Me., described by me in the Proc. Boston Society of Natural History. V.

IV. ASTRONOMY.

1. *Report on the Recent Eclipse of the Sun;* issued under the direction of the Superintendent of the Naval Observatory.—This handsome volume of more than 200 pages has appeared first of any of the reports of the government expeditions, only detached portions of those of the Nautical Almanac and Coast Survey having yet been published. Commodore B. F. Sands,

Supt. of the Naval Observatory, took early measures to secure thorough observations, and assigned four of the five professors and two of the other astronomers at that institution, to the duty of observing the eclipse. In pursuance of the plans Prof. Hall and Mr. Rogers repaired to Plover Bay, on the Asian shore of Behring's straits, Professors Newcomb, Harkness and Eastman established themselves at Des Moines in Iowa, and Mr. Bardwell went to Bristol, Penn. The War Department lent its assistance by detailing Dr. Curtis of the Army Medical Museum, who has won deserved distinction by his success in micro-photography, and who accompanied the Des Moines party. The volume contains reports from each of these gentlemen, and to these are added others from Mr. J. H. Lane, of Washington, from Mr. W. S. Gilman, Jr., of N. Y., a lover of astronomy who has given special attention to solar observations, and from Gen. A. J. Myer, chief signal officer of the army, who witnessed the eclipse from the summit of a mountain in Southwestern Virginia,—these with the prefatory introduction of Commodore Sands composing the work now issued, which is copiously illustrated with cuts and engravings.

Prof. Newcomb's point of observation was near the Court-house in Des Moines, latitude 41° 35′ 4″, on long. $1^{h}\ 6^{m}\ 17^{s}\cdot 0$ west from Washington. Following out the ideas previously suggested by him in this Journal, he affixed circular screens of different diameters to a horizontal arm, projecting from the gable end of the Court-house, so as to occult the sun for his points of observation; the largest being intended to hide the corona from the field of his 4-inch comet-seeker. After a sharp determination of the first contact with a power of 40, in this instrument, and an aperture reduced to one inch, he carefully pointed an 8-inch telescope, roughly mounted for the occasion, and the comet-seeker, to the sun at known moments; thus fixing their positions for the purpose of mapping the places of any objects which the totality might disclose in either field of view, after which he designed moving the telescopes into other positions, and counting any objects which might there be visible. Then retiring into a dark place, he awaited the total phase.

The corona appeared less bright than he had anticipated, and careful scrutiny along the ecliptic showed not the faintest trace of any flush of light extending beyond the rest in that direction. Nothing was visible in either of the two telescopes, nor did a sweep near the ecliptic with the comet-seeker disclose any object whatsoever. This important question being thus answered, and the visibility of any inferior planet or group capable of accounting for the motion of the perihelion of Mercury being made highly improbable, Prof. Newcomb proceeded to the study of the corona, with and without the aid of the comet-seeker. The great protuberance in the S.W. quadrant seemed to him strongly pink, not uniform in structure, nor at all resembling a flame, but like a huge pile of cumulus clouds, illuminated by white and red light. He was able to trace the corona with his naked eye only to a distance equal to the moon's semidiameter and he saw no long rays of light, but a jagged and serrated edge. The sky at Des Moines was however quite hazy. But seen through a green glass the corona seemed composed of four or five prominent portions, smooth in outline, shading away imperceptibly, and in no case exceeding 5′ in height. He regards the serrated appearance and the pointed rays as subjective phenomena. The moment of end of totality was noted with the naked eye, and the last contact with the comet-seeker, as before. Comparing his observations with the computed times, he finds the contacts to have occurred later than predicted by $12^{s}\cdot5$ for the first, $10^{s}\cdot4$ for the third, and $7^{s}\cdot8$ for the last; whence he infers

Peirce's ☽ — Hansen's ☉ is too great by $5''\cdot3$,
whereas, Hansen's ☽ — LeVerrier's ☉ is too great by 2·7.

Prof. Harkness constructed a building for himself, Prof. Eastman and Dr. Curtis at another point in the city of Des Moines, and determined his position as latitude $41°\ 35'\ 35''\cdot9$, long. $1^{h}\ 6^{m}\ 16^{s}\cdot05$ W. from Washington, by means of observations which are reproduced with great fullness of detail. At the beginning and end of the eclipse he was engaged with Dr. Curtis in taking photographs, upon which he had decided to rely for the times of first and last contact; but during the totality he devoted himself entirely to the spectroscope. With this he obtained, from a very bright part of the corona in the long beam to the southward, a continuous spectrum without absorption lines, but with a single bright line at 1497 of Kirchhoff's scale. From the great protuberance at 240° he obtained the lines C and F, that near D, and three others, two of which were *b* and the well-known third hydrogen line. The remaining one was that which he saw in the corona, and in all the protuberances without exception, and recorded as corresponding to K. 1497. It must we think have been K. 1474, which was recognized by so many other observers and which Lockyer and Young have always found in the chromosphere. The moderate dispersive power of Prof. Harkness's spectroscope would, as he states, render it difficult for him to discriminate with it between near lines.

Prof. Eastman's report contains the results of meteorological and photometric observations (which during the two days preceding the eclipse must have been far from encouraging), of observations of the contacts and of the corona. Of this and the appearances of the protuberances to him, he has given two colored engravings. In each the same outline serves for the corona; and indeed he expressly states that he "could not detect the least change in the color or position of the rays during totality." Beside these labors he assisted Prof. Harkness during the totality, by directing the spectroscope. Amid so many avocations it is surprising that Prof. Eastman could have accomplished so much, and that so well. We cannot avoid the conviction that had he been master of his own time during the total phase, he would not have failed to detect the decided fluctuations of form which the corona exhibited to more than one observer at Burlington. Like Prof. Newcomb, he found the color of the protuberances strongly red.

Dr. Curtis's report relates to the photographic operations which are described with very great minuteness. To those familiar with the exquisite photographs which he has made at the Army Med. Museum, it is needless to say that his preparations were evidently made with great forethought, and that abundant skill was displayed. A haze which veiled the sky, rendered a much larger exposure requisite than would otherwise have been given, but the photographs are of high excellence. The two taken during totality are given in engraved representations, impressions from the originals accompanying. These are very fine, rivaling those of the Burlington and Ottumwa parties. For the first, the exposure was 66 seconds; but details of the protuberances are beautifully shown, which would not have borne an exposure of one-third that length in a transparent atmosphere. Even the lunar motion seems scarcely to have interfered with the definiteness of the image.

It is to be regretted that a national enterprise carried out at the public expense should ever be made an agency for personal polemics, which indeed seem peculiarly out of place when aimed at any private citizen of the same nation, since he is theoretically one of those in whose behalf the investigation has been made. The greater part of one of the quarto pages is occupied by a note in fine print in which Dr. Gould is rather sharply assailed for his views as given on p. 435 of our last number. This is no place for any maintenance of those views, but two paragraphs deserve a word of comment.

"Dr. Gould adduces, as an additional argument in favor of his assumption, the observation that the long coronal beams appeared to him to be "variable," while the "aureole" photographed was evidently "constant" during the time of totality. This argument however loses some of its force when it is remembered that to other observers the corona appeared to the eye absolutely unchangeable both in form and position during the whole period of the total obscuration."

We are far from attributing to Dr. Curtis any intention of giving his language the discourteous significance which some might infer, otherwise no rejoinder could be possible. But we would suggest that special observations devoted to a particular point should *prima facie* outweigh general negative impressions. In the present case, if Dr. Gould's evidence be regarded as for any reason incompetent, there happens to be corroboration of his statement by other gentlemen whose attention he called to this point. And there is in addition the reasonable certainty that less than a twelvemonth will decide the question definitely, since attention will doubtless be specially directed to this point at the eclipse of Dec. next. Perhaps it might be the wisest, as it would certainly be the most considerate, course, to await such decision.

In the other passage Dr. Curtis says:—

". . . . the circumstance affords but another example . . . . of the necessity that a critic before attempting to draw scientific inferences from photographic representations should himself become something of a photographer. . . . . And by a singular coincidence, evidence that Dr. Gould has not a practical acquaintance with the art would seem to be afforded in this same published letter by his total misinterpretation of another purely photographic effect, viz: the apparent encroachment of the prominences upon the disk of the moon as seen in the photographs. This curious appearance, instead of being due to "specular reflection" is wholly a dark-room phenomenon, as will be explained in the text."

That Dr. Curtis's explanation is entirely adequate in most cases we readily concede. But when Ulloa in 1778 saw the brightness of the protuberances projected so far upon the lunar disk that he thought the sun was shining through a hole in the moon, there were no photographs. And had circumstances brought to Dr. Curtis's notice as many dozens of cases as have come to our knowledge, in which the great protuberance of last August was seen both by scientists and laymen, with and without optical aid, to appear as "a deep notch in the moon," we think he would have qualified his language. Dr. Gould has expressed his belief that this phenomenon is due to specular reflection from the lunar surface; others may with great reason attribute it to the influence of irradiation; but it cannot be solely a photographic effect, however such effects may coincide.

Dr. Curtis has also given the results of some interesting experiments made to determine the origin of the glow seen upon the sun, around the moon's limb, on the photographs; a glow which has been found real and not the result of contrast, in all the impressions taken last August. This he believes to be a result of diffraction, a view which we fully shared, as those present at the August session of the National Academy will remember. And by experiments involving diffractive action, he has produced artificial eclipse-photographs exhibiting the same appearance. But the recent experiments of Prof. Morton, of which Dr. Curtis must have been unaware, settled the question some time since by the production of other artificial eclipse-pictures by methods which exclude diffraction, yet manifest the crepuscule as clearly as in the original photographs. Such pictures have for a considerable time been in our possession, and Prof. Morton found the explanation of the phenomenon in a local redevelopment of the negative. This explanation seems fully to account for Dr. Curtis's results as well as for his own.

Mr. Lane's attention was given to teloscopic observation of the contacts and the corona; observations which were evidently carried out with his characteristic ability, but space is unfortunately wanting to us for a full description of his paper. Among other things, he measured the dimensions of two of the flocculent masses, or "cometoid bodies," in the protuberant aggregation at 110°; and he was able to trace the outline of the moon's eastern limb for $2^m\ 5^s$ after the end of the total obscuration.

Mr. Gilman's observations were made at Sioux City, Iowa, latitude 42° $47\frac{1}{2}'$, longitude $1^h\ 16^m\ 23^s$. His memoir is illustrated by numerous interesting diagrams, among which are sketches of spots and faculæ on August 5, 6, and 7. Some seconds previous to the occurrence of totality, the great protuberance and a large portion of the corona were seen by two of his companions. This protuberance (240°) was where Mr. Gilman had seen a bright double facula just before the first contact. Examined with a 4-inch telescope, it appeared of an orange-color, dotted with minute flakes of brilliant crimson. Another highly interesting fact is that four of the party saw an object which they confidently believed to be a star near the limits of the corona, in the neighborhood of the great protuberance. The position described was that of π *Cancri* [miswritten π *Leonis*, in *Astr. Nachr.*, lxxiv, 375] which was seen with one of the telescopes at Burlington. If this star was detected or seen by the unaided eye, no higher testimony could be brought to the keenness of the observer's vision; for its magnitude is but 5·8, being only three-tenths of a magnitude brighter than the faintest star visible to the average eye on moonless nights.

Mr. Bardwell, besides observing the times of contact, searched for inferior planets, and with the same negative results which others obtained.

Gen. Myer was at the summit of 'White Top Mountain,' near Abingdon, Va., 5,530 feet above the sea level. He saw the bright specks noted by so many as flitting across the moon's disk, and which some, erroneously, as we believe, have supposed to be meteors. With a deep-red shade-glass, "while some two digits of the sun were still uneclipsed," he noted a luminous prominence of yellowish color upon the moon's limb. Many of the details of the total phase were distinctly visible to the naked eye in this clear atmosphere, and when the last line of sunlight separated into beads, the guides exclaimed that the sun was breaking to pieces!

We have dwelt so long upon the observations within the territory of the United States, that no opportunity remains to give details regarding the observations of Prof. Hall at Behring's Straits (latitude 64° 20′, longitude 6^h 25^m). After their long voyage and hopeful endurance, they had the disappointment of seeing clouds drift over the sky, about an hour before the eclipse began. Within an hour after it had ended, the sky was cloudless again. The sun and moon were invisible from a short time before until a short time after totality, but the darkness was greatest between 9 17½ and 9 20 A. M.,—during which period there was less light than at the midnight preceding. The report is accompanied by copious meteorological and magnetic observations, which bear witness to the fullness of the preparations made, and testify that nothing within the control of Prof. Hall was wanting to render his results exceedingly valuable. Capt. S. R. Franklin of the United States Steamer Mohican, saw three protuberances upon the moon's disc, but no more. B. A. G.

2. *On the flight of a remarkable meteorite across the Western portion of Ohio near Forest*, lat. 40° 50′ and long. W., 84° 40′; by J. LAWRENCE SMITH, Louisville Ky.—A few minutes before three o'clock on the morning of Oct. 27th, the citizens of Forest, and for miles around, were suddenly aroused by a terrific sound in the upper regions like the report of a heavy siege gun, followed by two or three reports in quick succession, resembling the reports of field pieces fired by section, and ended in a peculiar and rather

metallic, rumbling or roaring sound, dying away in the distance. The interval between the first and successive reports was two or three seconds; the other intervals about one second. The firmest houses were shaken, windows rattled, and thousands of sleépers were roused in an instant, bewildered at the unusual and appaling noise; and many were the conjectures as to what it was; some thought it was an earthquake, but to the greater part it was simply an inexplicable phenomenon. Persons who happened to be awake at the time, were first startled to see the night suddenly lighted into day, and soon relapsed again into the usual darkness. While wondering what caused it, the stunning sound broke in upon them and greatly increased the mystery. The time between the going out of the light and the report is estimated by citizens here at from one-half to one minute.

Mr. Pierson of Patterson, a village about one mile, a little west of south of Forest, states that he saw the meteor coming directly toward him, from a direction about S. 35° W.; that it was a ball of fire apparently as large as a bucket, exceedingly bright and dazzling and had a luminous tail apparently thirty feet long and three feet wide; that it vanished or exploded, as he thought, directly overhead. At Finly, twenty miles northwest of Forest, the statement is, that there at about 3 o'clock on Wednesday morning, Oct. 28th, the inhabitants were aroused by a terrific explosion somewhere in the upper regions.

The night was one of clear moonlight, and exceedingly cold for the season. The night watchmen had witnessed it; and one says the he first saw it in the southeast, in size, seemingly, as large as a beer keg, and of intense brightness; that it descended, leaving a luminous streak behind, and that when near the earth, it exploded, with a terrific sound, and fierce brightness; that the light, after the explosion, took a southerly course, and disappeared. Another watchman reports that at the time of the explosion, it appeared as large as a load of hay, and that the sound of the explosion was stunning, not like a quick sharp report of thunder, but, as he termed it, more like the coming together of railroad cars, but much louder, and that the light was brighter than that of the sun. The direction of the meteor from Finley, as given by the watchman, with the bearing of the meteor's path, as described by Mr. Pierson of Patterson, and the fact, that to many the sound seemed nearly overhead, would indicate that it exploded or terminated its course in the vicinity of Forest; yet a careful investigation might prove its terminus to be many miles from that place. The sound seems to have been heard for perhaps fifty miles around, if not more. The stones or fragments that have fallen, may never be found, owing to the fact that the explosion was at night, and the consequent difficulty of determining its exact locality. In Kenton, Ohio, the phenomena are said to have occurred a few minutes before 3 o'clock and consequently they were not well observed; many persons saw the light but not the meteor, and all were sensible of the shock and sound. The meteor did not pass this place nearer than twenty miles, and the best judges give its duration at from two to three minutes from the flash to the explosion. The sound was of such force as to shake the houses and many believed it to be an earthquake.

These are all the statements I have been able to obtain in regard to the appearance of this meteor and its accompanying phenomena. It was beyond all doubt a meteorite, and I am using all possible means to discover any fragments that may have fallen. I must acknowledge the assistance afforded by Mr. Moore and Mr. Thomson, of Ohio.

3. *Elements of Asteroid* (109); by WM. A. ROGERS. (From a letter dated Alfred Observatory, Alfred, N. Y., Dec. 21st, 1869.) —I herewith communicate for the Journal the elements of (109) which I have computed from the following observations:

Date, W. M. T.	h. m. s.	Place of observation.	α ° ′ ″	δ ° ′ ″
Oct. 9,	13 26 32,	Hamilton Coll. Obs.,	14 00 45·9	+9 37 15·0.
Oct. 31,	8 44 33,	Hamilton Coll. Obs.,	9 11 27·8	9 54 47·8.
Oct. 31,	8 44 33,	Alfred Observatory,	9 11 32·4	9 54 48·0.
Nov. 28,	7 15 57,	Alfred Observatory,	8 7 49·2	11 9 3·17.

Epoch Oct. 9·0, W. M. T.

$$M = 339^\circ\ 16'\ 02''{\cdot}0$$

$$\text{Mean Eq. 1869·0}\begin{cases}\pi = 55\ 22\ 43{\cdot}3 \\ \Omega = 4\ 57\ 35{\cdot}2 \\ i = 8\ 4\ 10{\cdot}6\end{cases}$$

$$\varphi = 17\ 16\ 40{\cdot}7$$

$$\mu = 804{\cdot}8304''$$

$$\log a = {\cdot}4295348$$

For computing an ephemeris, I find:

$$\log x = 9{\cdot}9999681 + \log \sin (v + 145^\circ\ 19'\ 47''{\cdot}4)$$
$$\log y = 9{\cdot}9307966 + \log \sin (v + 55\ 45\ 21{\cdot}1)$$
$$\log z = 9{\cdot}7181204 + \log \sin (v + 54\ 11\ 42{\cdot}2)$$

V. MISCELLANEOUS BIBLIOGRAPHY.

1. *Exercises in Practical Chemistry*, by A. G. VERNON HARCOURT, M.A., F.R.S., Sec. C. S., and H. G. MADAN, M.A., F.C.S. Series 1st, Qualitative Exercises. 335 pp. 12mo, Oxford, at the Clarendon Press, 1869. London, Macmillan & Co.—This little volume is designed as the beginner's *vade mecum* in commencing the study of practical chemistry in the laboratory. No attempt at a systematic presentation of the elements of the science is here made. The novitiate is presumed to be equally innocent of nomenclature, symbols and philosophy and is led into the laboratory much as an apprentice to a trade, and is therefore first made familiar with his tools, and how to use them in the most simple operations before even attempting the preparation of oxygen and other gases. It is illustrated by sixty-five wood cuts, mostly new and many of them very effective. The nomenclature is that of Williamson. Symbols

expressing the more important reactions are given at the foot of the pages where needed. We look with interest for the second series on quantative chemistry.

2. *On Aniline and its derivatives. A Treatise upon the manufacture of Aniline and Analine Colors*, by M. REIMANN, P.D., L.A.M., to which is added, *The report on the coloring matters derived from coal tar, shown at the French Exhibition*, 1867; by Dr. A. W. HOFMANN, F.R.S., MM. G. de LAIRE, and CH. GIRARD. The whole revised and edited by WILLIAM CROOKES, F.R.S. &c. 8vo, pp. 164. (John Wiley and Son, Astor Place, New York, 1868.—Dr. Reimann's account of aniline and its derivatives is a fine example of the union of exact science, with practical skill, and as such teaches an important lesson beyond its special theme. It could not have had a more valuable supplement than in the admirable report of Dr. Hofmann and his associates, on the coal tar colors shown at the French Exhitition of 1867. The book, though published by Messrs. Wiley, was printed in London, by Mr. Crookes at the office of the Chemical News.

3. *A short Course in Qualitative Analysis, with the New Notation;* by J. M. CRAFTS, Prof. of General Chemistry in the Cornell University. 133 pp. 12mo, with five Tables. N. Y., 1869. (J. Wiley & Son.)—Prof. Crafts is well known to our readers from his frequent valued chemical contributions. He has, in the small volume before us, attempted the solution of a problem which every chemical instructor must meet whose duties call him to impart to a mixed class of academic students a maximum of knowledge in a minimum of time. A considerable portion of the first two chapters is devoted to an explanation of the theory of chemical reactions and nomenclature. The student is at once inducted into the notions of modern chemistry and familiarized with atomicity and the present chemical nomenclature. It is certain that under a good teacher any faithful student will master the main points of qualitative analysis by the time he has gone through the second part of this useful little volume. Only 34 of the 64 radicals known to chemists are treated of in this book. This brevity sometimes mars symmetry and renders the work of the student almost too simple, as when, for example, strontium is left out of group II. The tables IV and V, intended to record in a compact form the facts of analytical chemistry, are ingeniously devised by Mr. Perkins, to give the student exact ideas and methodical habits.

4. *The Fruits and Fruit trees of America, &c.;* by A. J. DOWNING. *Second revision and correction, with large additions*, by CHARLES DOWNING. pp. 1098, 8vo. New York, 1869. (John Wiley & Son).—Those cultivators of fruits who have been accustomed to handle the small duodecimo volume, which was left us by its lamented author under the above title, will hardly recognize their old acquaintance now grown to such portly dimensions. But the same rural flavor and discrimination are found in the work which Mr. Charles Downing has given us, that rendered the original edition of this work by his gifted brother a universal favorite on both sides of the Atlantic. But under Mr. Charles Downing's editorship

this work has become in fact a pomological encyclopedia, embracing a vast number of varieties of various fruits, which are of interest to the curious reader rather than the cultivator. For example, not less than 2800 varieties and synonyms of the pear are mentioned, while few cultivators in the Eastern United States plant over twenty or thirty sorts. Fortunately for the novice in pomology, Mr. Downing adds well considered select lists of the various fruits, that of the pear containing about seventy varieties, which serve to redeem the planter from chaos. The chapter on the grape, is enriched by well drawn figures of the most approved sorts of American origin, most of which have been produced by cultivation since 1845, when the first edition of Downing was published. It would have been well if the general introduction to this fruit had been rewritten or extended to embrace important new matters, as the sulphur treatment for *Oidium Tuckeii*, the later researches on the insects infecting the vine, and the considerable experiences which twenty years have given us, relating to vineyard culture and American vines.

The title of this book reminds us that its contents do not correspond to what it calls for. To one familiar with fruit culture as it exists on the Pacific coast of the United States, Mr. Downing's book appears more foreign than any European work on horticulture can to a cultivator living upon the Atlantic shores of the continent. It would have given a completeness to the work, if it had briefly sketched the main peculiarities of the most remarkable fruit-growing region of North America.

5. *Agricultural Qualitative and Quantitative Chemical Analysis*, (after E. Wolff, Fresenius, Krocker and others), by G. C. Caldwell, Professor of Agricultural Chemistry in the Cornell University. 300 pp. New York; (Orange Judd & Co.).—This work, prepared from the best sources in a thoroughly conscientious and judicious manner, supplies a want now beginning to be seriously felt in this country.

Prof. Caldwell's book is intended to serve as a complete manual of chemical analysis for the use of agricultural students. The titles of its chapters are—I, Reagents. II, Analytical Operations. III, Reactions and Methods of Quantitative Estimations. IV, Special methods of Analysis, viz: Course in Qualitative Analysis, including the elements encountered in Soils, Plants and Agricultural Products, Estimation of Water, Organic Matter, Sulphur and Chlorine in Organic Compounds, Separation and Estimation of the Alkalies, Alkali-Earths, Alumina, oxyds of iron and manganese, silica and phosphoric acid. V, Analysis of Soils, Rocks and Marls. VI, Analysis and Valuation of Fertilizers. VII, Ash-Analysis. VIII, Analysis of Fodder and Food. IX, Wool and Bark. X, Beverages. XI, Tables. We trust that this volume will be studied and used by every student in our Agricultural Colleges, for the knowledge that can be acquired only by following and by applying its methods is not only of the utmost importance to the individual farmer, but bears most seriously upon the development and conservation of our greatest national resource, the productive power of our soil. J.

6. *Lithologie des Mers de l'ancien monde, par* M. DELESSE.—We have received from the author two beautiful charts, illustrating the above work, which we propose to notice in another number.

7. *Hydraulic Motors;* translated from the French cours de Mécanique appliqué, par M. BRESSE, Professeur de Mécanique a l'Ecole des Pronts et Chaussées, by F. A. MAHAN, Lieutenant U. S. Corps of Engineers. Revised by D. H. Mahan, LL.D., Professor of Civil Engineering, &c., United States Military Academy. 165 pp. 8vo. 1869. New York, (John Wiley & Son.)—A convenient and thorough treatise on the subject of Hydraulic Motors.

8. *Weisbach's Manual of Mechanics,* vol. i, part II, 8vo. New York, (D. Van Nostrand).—The second part of the first volume of Weisbach's Mechanics, noticed in our last volume (p. 449), has just been received.

9. *A Practical Treatise on Metallurgy, adopted from the last German Edition of Kerl's Metallurgy;* by WILLIAM CROOKES, F.R.S., and ERNST RÖHRIG, Ph.D., M.E. In three large volumes, 8vo. London, (Longmans & Co.; New York, John Wiley & Son, 2 Clinton Hall, Astor Place.)—These volumes take up the subjects in the following order: Vol. I, Lead, Silver, Zinc, Cadmium, Tin, Mercury, Bismuth, Antimony, Nickel, Arsenic, Gold, Platinum, Sulphur. Illustrated by 207 wood engravings. 724, pp. 1868. Vol. II, Copper, Iron. Illustrated with 273 wood engravings. pp. 876, 1869. Vol. III, Steel, Fuel; Supplement. Illustrated with 145 woodcuts. 803, pp. 1870. We have no space at this time for a further notice.

10. *Reliquiæ Aquitanicæ;* by Messrs. LARTET & CHRISTY, edited by Prof. Thomas Rupert Jones. Part ix, of this beautiful work on the Archæology of Southern France, has been published.

Lea on the Genus Unio. Index to Vol. XII and supplementary index to Vols. I to XI of Observations on the Genus Unio, together with Description of new species of the Family Unionidæ and description of new species of Melanidæ, Paludinæ, Helicidæ, etc. Isaac Lea, LL.D., etc. Philadelphia, 1869.

Bulletin of the National Association of Wool Manufacturers. Oct., 1869. Boston.

Address delivered on the Centennial Anniversary of the birth of Alexander von Humboldt under the auspices of the Boston Society of Natural History, by Louis Agassiz. Boston, 1869. 108 pp. 8vo.

Mammalia of Massachusetts, by J. A. Allen. 112 pp. 8vo. Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass. No. 8. 1869.

ALEXANDER VON HUMBOLDT, eine wissenchaftliche Biographie, by Dr. Carl Bruhns, aided by various Savans of Germany, is soon to be issued in two large volumes by F. A. Brockhaus of Leipzig.

OBITUARY.—THOMAS GRAHAM, author of the excellent "Elements of Chemistry," and since 1855 Master of the Mint, died Sept. 16th, in his 64th year.

AXEL JOACHIM ERDMANN, Director of the Geological Survey of Sweden, and eminent in Mineralogy as well as Geology, died at Stockholm on the 1st of December last, at the age of 55 years.

O. L. ERDMANN, the distinguished Chemist, and editor of the Journal für praktische Chemie since 1843, died on the 9th of October at Leipzig, aged 65 years.

MICHAEL SARS, the eminent zoologist of Norway, and one of the first in Europe, died at Christiania on the 22nd of October last, at the age of 65 years. The last of his remarkable memoirs is noticed in the last volume of this Journal, (p. 142).

THE

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[SECOND SERIES.]

ART. XVII.—*Photometric Experiments.* PART FIRST.—*On a simple form of Photometer for determining the amount of Light reflected by Metallic Surfaces at different incidences;* by OGDEN N. ROOD, Prof. of Physics in Columbia College.

THE fundamental idea of many forms of photometer is based on the comparison of two illuminated surfaces placed in immediate juxta-position, and the judgment of the experimenter is called on to decide when the brightness of these appears equal. If the difference of the two rival surfaces be considerable, the inequality will be perceived even by an unpracticed eye, but as the disparity is diminished the observer becomes less confident, and, passing into a doubtful and dissatisfied frame of mind, is at one moment inclined to consider the balance as gained, and at the next equally certain that it has been lost. It hence follows that no photometer of this form is adapted for investigations at all aiming at a refined character.

Bunsen, to whom Physics as well as Chemistry is under so many obligations, employs in the instrument which bears his name another principle: here, it is not the equality in the brightness of two adjacent surfaces, but the actual disappearance of a "spot" on an illuminated ground, the powers of the observer being now taxed to a much less extent, as it is merely a question of the visibility or invisibility of the "spot." The great superiority of this latter principle is evident from the mere statement, and it only remains to investigate how the proposed advantage can best be realized in actual practice. It is, I believe, generally admitted by those who have used Bunsen's photometer, that with it, the end proposed is only approximately attained, the spot never becoming absolutely invisible, but merely assuming what may be termed an appearance of maximum faintness. Dove* has proposed a form of photometer, the general idea of which is not unlike that of Bunsen; it consists of a compound microscope provided with a microscopic photograph on glass, which serves as the "screen," the intention being to illuminate it from both sides, in such a way that the photograph should assume the same degree of brightness with its own border or ground, and hence become invisible after compensation. In a former number of this journal† I described a form of photometer partly based on this suggestion of Dove's, and at the same time detailed a few rough experiments that were made by its aid. Since then I have followed up the subject, and have examined somewhat, with the help of a more refined apparatus, the practical application of the physical and physiological principles involved in its more perfect construction and use.

The microscope and microscopic photograph I dispense with, gaining thus not only in economy but also in delicacy, while the plan of employing a silver-collodion film on glass was retained and proved of great value, and, as will be shown in the second part of this paper, the idea of a total disappearance of the "spot" was at length realized to the fullest extent, when the precaution of using an absolutely unvarying illumination was observed. I proceed now to describe the instrument, and will afterward add some determinations that were made by its help.

Description of the instrument. "*The Screen.*"—If we take a plate of glass covered by an opaque preparation, with a surface of some reflecting power, but without polish, and laying bare a small portion of the glass, say $\frac{2}{16}$ of an inch square and having backed it up by a plate of ground glass, illuminate it front and rear by two lights, it is evident that a mass of light will be reflected to the eye of the observer from the opaque pigment, while light coming from the second source will traverse the naked portion of the plate and reach the same destination. This second portion, or that coming from the "spot," will have commonly a greater or lesser degree of intensity than that *reflected* from the adjacent regions of the plate, so that we shall have either a bright spot on a dark ground, or a dark spot on a light ground, and an attempt to equalize the two illuminations, so as to effect the disappearance of the "spot," will be successful only under the following conditions:

First. All portions of the "spot" must be equally illuminated, and it must have no texture, that is, must not perceptibly consist of minute grains mingled with others having a less or greater degree of brilliancy.

* Pogg. Annalen, Band cxiv, p. 145. † Vol. xxxvi, July, 1863.

Second. All those portions of the ground surrounding and in contact with the "spot," must be equally illuminated, and the texture of the ground must likewise be uniform.

Third. The transition from the ground to the "spot" must be perfectly sharp and sudden, so that not the faintest border can be seen surrounding it.

Fourth. If it be required to render the invisibility of the "spot" more than momentary, it is equally essential that the ratio subsisting between the two sources of illumination should be truly constant.

If either of the first three precautions be neglected, the disappearance of the spot becomes entirely impossible, while it is only by a peculiar arrangement of apparatus that the fourth can actually be realized. (See second part of this article.)

Screen.—A plate of colorless glass of good quality is coated with photographic collodion and immersed for a few minutes in a solution of nitrate of silver, ("bath,") as though it was the intention to take a picture, ("negative"); it is then exposed for a minute or less to ordinary daylight, and a solution of photo-sulphate of iron poured over it. This produces a dense opaque deposit of silver in the substance of the film, when the plate is to be washed well in plain water and dried. Its surface will be of a grey tint, and will vary somewhat in its power of diffuse reflection according to the sample of collodion used. A small amount of light is also regularly reflected by the upper surface of the collodion film, and in using the plate it is always so placed that this latter portion shall produce no effect on the result. The collodion film is now removed neatly, by the aid of a needle, from a portion of the plate, so that a square with sides $\frac{2}{10}$ of an inch is laid bare, care being taken to leave the edges clean and well defined, in which there is no particular difficulty, provided the collodion was originally of the proper quality to cause it to adhere well. If the "spot" is made much smaller than the above mentioned dimensions it becomes an annoying object for observation, while if it be larger, it is difficult to illuminate it

1.

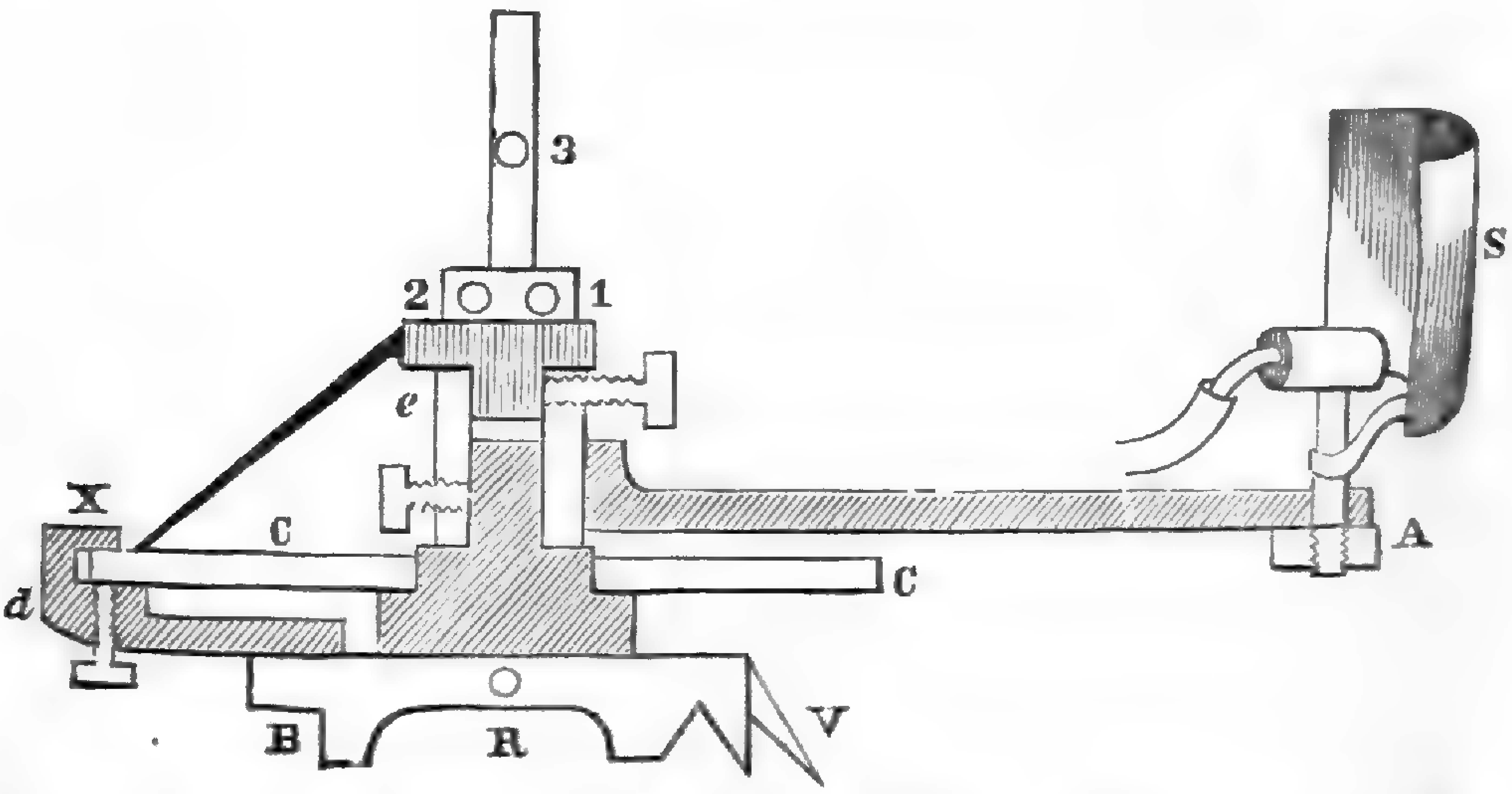
uniformly. This plate is seen at P, in figure 1, the collodion side being turned toward the eye of the observer, and the other side, except just opposite the spot, covered by a coating of lamp-black mixed with weak shellac varnish, so as to leave a black, non-reflecting surface. At the distance of an inch from the collodion plate, there is fastened, parallel to it, a plate of colorless glass, G, finely ground on each side; this is destined to receive the light from L. If only one surface of the glass be ground, the texture becomes plainly visible, particularly when, as in the experiments detailed in the second part of this paper, the spot is magnified. Only so much of the ground glass plate is allowed to remain bare as is necessary, the remaining portions on both sides are covered by black non-reflecting paper. Plates P and G are then as it were roofed over, and enclosed on all sides by a small well fitting blackened case, destined to prevent the light from penetrating between them, and finally, to guard against possible errors by reflection from the walls of the room, plate G is provided with a projecting blackened tube which cuts off stray reflected light. P and G, constituting thus the screen, are fastened at the end of a pair of long parallel iron bars, B, B, made like the ways of a lathe, and provided with a scale graduated in millimeters. The length of this iron frame is six feet.

Source of illumination.—At E is the eye of the observer, the face being protected from light by the blackened screen, S. E, the center of the "spot," and the center of the mirror experimented on, all lie in the same line, which is of course at the same time the axis of the instrument. At H are two small gas flames issuing from circular apertures, and destined to illuminate the collodion plate on the side next to the observer; both are fed from the same source. The gas-burner at H consists of two thin brass tubes, half an inch in diameter and one inch long, connected together by a glass tube; the circular apertures for the flames are placed at equal distances on either side of the spot, and as far from it as is found most advantageous in any particular set of experiments; their distance from each other is seven inches. The direct light from the two flames is prevented from reaching the eye through the observing aperture, by small blackened screens, the same means being employed to arrest it in its course toward L. If instead of two, only a *single* gas flame is employed at H, the ground around the spot will be unequally illuminated, and exact observations become impossible. Of course the direct light from these two burners which penetrates through the "spot," must not be allowed to reach that portion of the ground glass opposite it; the distance of the flames apart must be so chosen that this becomes impossible.

The light from the movable burner on the other side of the screen at L will be used direct and reflected. The small *single* movable burner which supplies it, is similar to those already described, and to it is attached a flexible india-rubber tube, which is supplied from the same source that feeds H; it is connected by a *wooden* column, (for the sake of insulating the heat,) to the arm A, fig. 2.

I pass now to the joint support of the arm, A, and of the mirror to be experimented on. It consists of a block of brass,

2.



B, four inches square (see figure 2, which is one-third of the real size); its under surface is cut in such a way as to fit the two parallel iron bars and to slide on them easily but steadily, and this foundation block is farther provided with a vernier, V, to read off the distances on the millimeter scale. C is a graduated circle six inches in diameter, and is provided with a clamp at *d*. The hollow massive cylinder, *e*, supports the arm A, and also carries the axis of the support of the mirror. The screws, 1, 2, 3, serve to bring the mirror into its correct position; it is pressed against them by a band of india-rubber attached to the edges of the mirror. It will be seen that owing to this arrangement, all the different parts have motions quite independent, and yet by the clamping screws can at any moment be connected. Finally, attached to this stand is a long light rod of wood, R, reaching to the observer, and enabling him, by varying the distance between this movable piece and the fixed screen, to effect compensation.

Flexible Gas tubes.—It occurred to me that by splitting a stream of gas and sending one portion to L, fig. 1, the other to H, it would be possible to secure a uniform ratio between the two illuminations, as it would seem that any cause which increased the pressure in one of the branches of the tube ought to be equally operative in the other, so that after a compensation had been effected it should be permanent. In practice this was not found to be the case; the compensation point gradually shifted its position in the course of the evening away from H, sometimes to the extent of 50 or 60 millemeters. This difficulty was remedied by a suggestion from Mr. Lewis Rutherfurd, who suspected that the trouble came from the unequal length of the two branches of the supply tubing, in point of fact, on giving them equal lengths and diameters, and making the compensations slowly, so that the branch attached to L was not much shaken or set in oscillation, this source of error became so greatly reduced as in no way to interfere with the observations.

Mode of measuring the amount of light reflected from a mirror.—To adjust the apparatus, it is first necessary that that diameter of the circle joining the 0° and 180° points, should be made parallel to the axis of the instrument, which is effected by the use of the vernier at X, fig. 2, the circle is then clamped. Next, the vernier attached to the mirror is placed at 90°, and the mirror itself is made to assume a position at right angles to the axis of the instrument, by the aid of its three screws, and a small gas flame placed on a support which rests on the parallel bars at a distance of two or three feet from the mirror, it being so contrived that the center of this small flame shall just lie in the axis of the instrument. The mirror is adjusted till it reflects the light of this small flame back to the eye through the flame itself, securing thus the collimation with the desired accuracy. The arm A is then set at any desired angle with the mirror, and the two clamped together, when it is easy to arrange matters so that the reflected light shall be sent from the mirror along the axis of the instrument to the fixed screen at G. The small shade at S, fig. 2, prevents the *direct* light from reaching the same destination. After a compensation has been effected with reflected light, the arm A is made parallel with the axis of the photometer by the aid of its vernier, and another compensation is made with the *direct* light, the small shade being now placed behind the flame so as to be out of the way and to prevent light from reaching the mirror.

Mode of registering the observations.—These were always registered with a sharp point on a slender fillet of paper, attached to the long wooden rod R T, fig. 9, used for moving the mirror. This point was one end of a small lever placed at N, fig. 1. In consequence of this, at the end of a set of experiments two groups of dots were found on the paper, admitting of the most exact measurement on the following day. Before removing the paper from the rod two dots were always made on it in the neighborhood of these groups, the corresponding positions of the vernier V, fig. 2, being at the same time noted. A glass slide, ruled with millimeter lines, was then to be placed over the detached fillet of paper, and the observations recorded in the note-book. In the determinations given below, the observations on the direct and reflected light were made alternate, so as to avoid errors due to the shifting of the compensation point.

Observations on the amount of light reflected by a glass plate silvered by Liebig's process, the *silver* side being used. The light was reflected at an angle of 45°.

1.

Distance when mirror was used.	Distance with free flame.
946	1297
949	1301
950	1302
951	1302
952	1304
955	1305
956	1306
957	1308
958	1309
961	1309
961	1310
962	1312
965	1312
966	1315
967	1318
967	
	15)19610
16)15323	
	1307·3
957·68	105·
Correction 191·	
	1202·3
1148·68	

Result 91·26 per cent reflected.

2.

Distance when mirror was used.	Distance with free flame.
936	1286
940	1287
941	1288
942	1288
943	1290
944	1292
946	1292
946	1293
947	1295
948	1296
949	1297
950	1298
952	1298
953	1301
954	1303
955	1303
956	1304
958	1305
959	1307
960	1307
961	1307
962	1308
965	1312
	1312
23)21867	1312
	1315
950·7	
Correction 191·	26)33796
1141·7	1299·8
	Correction 105·
	1194·8

Result 91·3 per cent reflected.

These figures are taken of course directly from the note-book, and in making an examination of them it is to be remembered that the corrections, 191 and 105, (for false positions of the vernier), are to be applied to each of the distances in the respective columns, before a correct judgment of the closeness of individual observations can be made.

When the same mirror was used at 5°, i. e., the light being reflected from it nearly perpendicularly, the results given below were obtained.

1.

Distance when mirror was used.	Distance with free flame.
955	1297
958	1304
958	1304
958	1305
960	1305
962	1307
962	1308
963	1310
963	1310
965	1313
965	1313
969	1313
970	1314
971	1314
972	1315
973	1318
977	1318
977	1328
980	
983	18)23596
983	
	1310·8
21)20324	105
967·8	1205·8
191	
1158·8	

Result, 92·35 per cent reflected.

2.

Distance when mirror was used.	Distance with free flame.
954	1298
955	1301
956	1302
957	1303
957	1303
958	1304
958	1305
961	1306
961	1307
962	1308
962	1308
963	1309
963	1310
964	1312
965	1312
967	1313
968	1315
969	1316
972	
	18)23532
19)18272	
	1307·4
961·6	105
191·	
	1202·4
1152·6	

Result, 91·88 per cent reflected.

In the second part of this paper I shall detail the results of several sets of experiments made with a truly constant illumination, in other respects the mode of experimenting being quite similar to that used in obtaining the above results, when it will be seen that about two-thirds of the scattering in the figures was due to the shifting of the compensation point during the experiments, and not to any defect in the screen.

In the same way experiments were made on another mirror silvered by Liebig's process, the glass side being used, with the result that out of a hundred rays 78·01 were reflected, the angle being 45°; while an amalgam mirror tested at the same angle reflected only 44·58 per cent.

Art. XVIII.—*Contributions to the Chemistry of Copper;* by T. Sterry Hunt, LL.D., F.R.S. Part 1.

[Read before the American Association for the Advancement of Science at Salem, August 25, 1869.]

§ 1. The resemblances between silver and copper in its cuprous form have already attracted the attention of chemists. The ordinary chlorid of silver (argentic chlorid) and the dichlorid of copper (cuprous chlorid) have many properties in common. Both of these chlorids are white, readily fusible, and blackened by exposure to light; both of them are insoluble in water but dissolve in ammonia and in aqueous solutions of other chlorids, in which however the cuprous is far more soluble than the argentic chlorid. A saturated solution of chlorid of sodium holds at 90° Centigrade, 16·9 per cent of cuprous chlorid, at 40° C., 11·7, and at 11°, 8·9 per cent. A solution containing fifteen per cent of chlorid of sodium retains at 90° C., 10·3 per cent of cuprous chlorid, at 40°, 6·0 per cent, and at 14°, 3·6 per cent; while a solution with only five per cent of chlorid of sodium holds of the cuprous chlorid at 90°, 2·6, and at 40° only 1·1 per cent. These determinations are from single observations and therefore require verification. From the sparing solubility of the cuprous chlorid in dilute solutions of chlorid of sodium it follows that the denser saturated solutions are copiously precipitated by dilution with water, which causes the separation of white cuprous chlorid in a crystalline condition.

§ 2. The aqueous solutions of the chlorids of calcium, magnesium, zinc, manganese, cobalt, ferrosum and cupricum, also freely dissolve cuprous chlorid, and it is probable that this property is shared by other soluble chlorids. The strong affinity of cuprosum for chlorine enables cuprous oxyd to decompose all the chlorids just named, with the exception of those of sodium and calcium, with separation of the corresponding oxyds and formation of cuprous chlorid. In the case of zinc and manganese, insoluble oxychlorids of these metals are formed at the same time. These reactions require further study, and the same may be said of the cupric and cobaltic chlorids with cuprous oxyd. I have, however, partially investigated the behavior of cuprous oxyd with magnesic and ferrous chlorids, and obtained the results about to be described.

§ 3. The cuprous oxyd for these experiments was prepared by gently heating a solution of sulphate of copper mixed with cane sugar and an excess of caustic soda, until the whole of the copper was thrown down as a bright dense cinnabar-red powder which was carefully washed and dried. A concentrated solution of chlorid of magnesium dissolves this oxyd in the cold, and more readily when heated, with separation of hydrated oxyd of magnesium and cuprous chlorid, which latter is held in solution by the excess of magnesic chlorid. By filtering the liquid while hot, and washing with a strong solution of chlorid of sodium, the hydrate of magnesia may be separated, and the dissolved copper subsequently precipitated by metallic iron from the colorless filtrate, ferrous chlorid being formed. Experiment shows that the reaction between the red oxyd of copper and chlorid of magnesium may be represented as follows: $Cu_2O+MgCl=Cu_2Cl+MgO$.

§ 4. A solution of magnesian chlorid nearly saturated when hot with cuprous oxyd, and allowed to cool in contact with the precipitated magnesian hydrate, deposits a portion of orange colored oxyd, or perhaps an oxychlorid, which disappears as often as the solution is heated. The solid cuprous chlorid is moreover decomposed when digested with water and magnesia, hydrated cuprous oxyd and magnesic chlorid being formed. The double chlorid of cuprosum and magnesium is however stable, even in the cold, in presence of magnesian hydrate, provided a considerable excess of magnesian chlorid be present. From a filtered solution of cuprous oxyd in chlorid of magnesium water precipitates a large portion of the cuprous chlorid, in this case colored orange-yellow from adhering oxyd, due to the reaction of a little magnesia, which remains dissolved or suspended in the concentrated solution even after filtration. A solution of magnesian chlorid of specific gravity 1·23, retains in solution at 12° Centigrade, about 7·10 per cent of cuprous chlorid. A solution of magnesian sulphate with chlorid of sodium may be employed to dissolve cuprous oxyd. This, like all similar solutions of cuprous chlorid, rapidly absorbs oxygen from the air and deposits a pale green cupric oxychlorid.

§ 5. With ferrous chlorid and cuprous oxyd it might be expected, from analogy with the magnesian salt, that we should obtain cuprous chlorid and ferrous oxyd, but the reaction is complicated by the tendency of the latter to pass to the state of ferric oxyd. When ferrous chlorid in solution with chlorid of sodium is heated with a sufficient quantity of cuprous oxyd, the whole of the iron is precipitated as ferric oxyd, mingled with metallic copper, while cuprous chlorid remains in solution. Experiments made with an excess of ferrous chlorid show that one third of the copper is reduced, while two thirds are dissolved as dichlorid. This reduction may be effected directly by ferrous oxyd; if to a solution of cuprous chlorid in chlorid of sodium, we add hydrated ferrous oxyd recently precipitated by an alkaline base and still suspended in the liquid, it is at once converted into ferric oxyd, with precipitation of metallic copper. The first stage in the action of ferrous chlorid on cuprous oxyd may be represented as similar to that of magnesic chlorid: $Cu_2O + FeCl = Cu_2Cl + FeO$. In the second stage $Cu_2Cl + 3FeO = Cu_2 + FeCl + Fe_2O_3$. It follows from this that one-third of the cuprous chlorid formed in the first stage is reduced to the metallic state, and the final result may be represented as follows: $3Cu_2O + 2FeCl = 2Cu_2Cl + 2Cu + Fe_2O_3$.

A similar result is obtained if ferrous chlorid is added to an unfiltered solution of cuprous oxyd in chlorid of magnesium. The suspended hydrate of magnesia in this case liberates an equivalent of ferrous oxyd, which reduces to the metallic state one-third of the dissolved cuprous chlorid, in accordance with the second reaction given above.

§ 6. The reducing power of ferrous oxyd is also shown with cupric chlorid, which is at once converted by it into cuprous chlorid in accordance with the equation, $2CuCl + 3FeO = Cu_2Cl + FeCl + Fe_2O_3$. The further action of ferrous oxyd will, as we have seen, reduce the cuprous chlorid to the metallic state: in fact, $2CuCl + 6FeO = 2Cu + 2FeCl + 2Fe_2O_3$. If recently precipitated hydrated ferrous oxyd or ferrous carbonate be added to a solution of cupric chlorid in the proportions indicated by the last equation, the whole of the copper is separated in the metallic state, mingled with ferric oxyd, while ferrous chlorid is found in solution. The reaction with ferrous carbonate, which requires a gentle heat, is accompanied by a violent disengagement of carbonic acid gas. This experiment is best made by dissolving in water ferrous sulphate and sodic carbonate or sodic hydrate in the proportions required, and adding thereto a solution holding the proper amount of cupric chlorid. Under certain conditions the cuprous precipitate is brownish-black in color, like that obtained by heating ferrous chlorid with cuprous oxyd, but more generally it is of a bright red color, and often coats the glass with a mirror-like film. A warm solution of cupric chlorid with chlorid of sodium at once converts the metallic copper of the precipitate into cuprous chlorid, which is dissolved, leaving behind only hydrated ferric oxyd. When a solution of ferrous chlorid with chlorid of ammonium and excess of ammonia is added to a solution of a copper salt the precipitated films of metallic copper sometimes possess considerable brilliancy and show a bluish translucency. It is to be remarked that although the cupreous precipitate thus obtained is bright red in color, that which is produced by boiling cuprous oxyd with ferrous chlorid is nearly black.

§ 7. It was long since shown by Levol that hydrated ferrous oxyd will reduce cupric to cuprous oxyd, and this, as we have already seen, can separate from its combinations ferrous oxyd, whose reducing power may be still further exerted upon the cuprous combination thus formed. These facts serve to explain the results obtained by E. Braun (*Zeitschr. Chem.*, 1867, p. 568, cited in *Jahresbericht* for 1867), which were not known to me at the time of making these experiments. He found that by digesting cupric hydrate or cupric carbonate with ferrous sulphate in solution there was obtained a reddish mixture of basic ferric sulphate with cuprous oxyd, formed apparently in accordance with the equation,

$$2FeO, SO_3+2CuO=Cu_2O+Fe_2O_3, 2SO_3.$$

This, when boiled with a further portion of ferrous sulphate, became black in color, and from the small amount of oxygen present was supposed to contain metallic copper. By adding a large excess of carbonate of ammonia to a mixture of ferrous and cupric sulphates, Braun succeeded in obtaining solutions in which all the copper was present in a cuprous form, and even in reducing portions of it to the metallic state, a process which we have seen is complete when the requisite amount of ferrous oxyd is brought in contact with the chlorids of copper.

§8. In this Journal for March, 1867, page 308, I described briefly the reaction between cupric oxyd and ferrous chlorid, according to the equation, $3CuO+2FCl = Fe_2O_3+Cu_2Cl+CuCl$. I was not then aware that the same had been shown by Meyer (Berg. und Hutt. Zeit., 1862, 182, cited by Kerl).* Further studies of this reaction have given me interesting results. The black oxyd of copper, even after ignition, is attacked by ferrous chlorid in the cold, but the insolubility of the resulting cuprous chlorid retards the action. If however the ferrous chlorid be mingled with a strong solution of chlorid of sodium, and heat applied, the cuprous chlorid is readily dissolved, and the reaction is rapid and complete, the whole of the iron separating as a bulky reddish-brown precipitate, provided three equivalents of cupric oxyd have been taken for two of ferrous chlorid. The greenish solution thus obtained readily dissolves precipitated metallic copper, in virtue of the cupric chlorid which it contains, and, unless a large excess of chlorid of sodium be present, deposits white crystalline cuprous chlorid by cooling or by dilution. When digested at a temperature of 50° Centigrade with carbonate of lime, the greenish solution deposits one-third of its copper as a pale green insoluble cupric hydro-carbonate, while the colorless filtrate retains the remaining two-thirds in the form of cuprous chlorid. If a solution of ferrous chlorid with chlorid of sodium is digested with a sufficient excess of cupric oxyd the cupric chlorid formed unites with the latter to form an insoluble cupric oxychlorid, and only cuprous chlorid remains in solution.

* Metall. Huttenkunde, xi, 588.

§ 9. For the ferrous chlorid in the experiments in § 5 and § 8, a solution of ferrous sulphate with chlorid of sodium may be substituted. When cupric oxyd is heated with an excess of ferrous chlorid, a small portion of ferric oxychlorid is produced. The red-brown precipitate may be washed free from cupric, cuprous and ferrous chlorids by a strong solution of chlorid of sodium, but will then yield to pure water a portion of soluble ferric oxychlorid. By careful desiccation in a water-bath and subsequent washing with dilute alcohol the ferric precipitate may be obtained free from chlorid of sodium, and completely insoluble in water; but its composition appears to be variable. Of two preparations the first contained one equivalent of chlorine for eleven, and the second, one for twenty equivalents of iron. In another experiment where fine oxyd of copper from the calcination of malachite was dissolved in an excess of a mixture of ferrous sulphate and chlorid of sodium at a boiling heat, it was found that for thirty equivalents of copper dissolved there were precipitated twenty-one equivalents of iron, instead of twenty as required by the formula given in § 8; the additional equivalent being separated as ferric chlorid in union with the ferric oxyd. The production of a small and variable amount of ferric chlorid in the above conditions is apparently due to a secondary reaction between cupric and ferrous chlorids in the presence of ferric oxyd; $2CuCl + 2FeCl = Cu_2Cl + Fe_2Cl_3$. This point however requires further investigation.

§ 10. The facility with which cupric chlorid parts with one-half of its chlorine and passes into the more stable cuprous compound is shown by its well known power to chloridize not only metallic copper, but metallic silver and even sulphid of silver. Its action on cuprous sulphid is not less remarkable. A strong solution of cupric chlorid mingled with chlorid of sodium rapidly attacks pulverized copper-glance, even in the cold, sulphur being separated and cuprous chlorid formed; $2CuCl + Cu_2S = 2Cu_2Cl + S$. Chalcopyrite, on the contrary, is but slightly acted upon by such a solution, which, however, slowly takes up a portion of iron, forming ferrous chlorid with a corresponding amount of cuprous chlorid.

ART. XIX.- -*Notice of a recent Land-slide on Mount Passaconaway*; by GEO. H. PERKINS, Ph.D., Prof. Zoology and Geology, University of Vermont.

THE name Passaconaway is given to a somewhat extended mountain in Grafton county, New Hampshire, twenty miles northeast of Plymouth, and about the same distance southwest of Mount Washington. It consists mainly of three conical peaks of nearly equal height, which form a group at the southern end, and of a high ridge running several miles northeast. A much smaller ridge stretches in a southerly direction. During the great rain of October 4th, there was an unusually large land-slide upon the southwestern slope of the most southern of the three highest summits. The light-colored streak down the mountain side, which marked the course of the slide, could be distinctly seen for more than fifty miles. It was at this distance that I first saw it, two weeks after its occurrence, and with my friend Rev. M. T. Runnels of Sanbornton, set out to examine it. At Campton we were joined by Mr. Chas. Cutter, to whose knowledge of the region and general kindness, much of our success was due. From Campton a ride of ten miles in a northeasterly direction up Mad River valley brought us to Waterville; thence we proceeded on foot. After walking two or three miles we reached a level clearing of fifty acres through which Mad river runs, here only a few yards across. This space was covered with great heaps of logs, some of them very large, brought down from the débris of the slide during the freshet that attended or followed it. That they came from the slide was very evident, for nearly all were broken as if suddenly snapped in two, many had one or both ends crushed to splinters so fine that they seemed like great brushes, and all were entirely stripped of foliage and of most of the smaller branches.

These logs were mainly spruce, and some were fifty to sixty feet long, and one to two feet in diameter. They were piled up in great confusion to the height of fifteen or twenty feet. Subsequent investigation showed that this was at least three miles below the terminus of the slide. Nowhere else was there such a mass of timber as here, nor any where else was the ground so favorable for such an accumulation; for elsewhere the banks of the stream were high and rocky, and not more than eight to twelve rods apart.

The whole mountain is covered to the very top with a forest of spruce, and to reach the slide most easily we followed the bed of the stream along its side. At short intervals were piles of logs more or less broken, by which the stream had evidently been in several places completely dammed.

Trees on the banks twenty feet or more above the water were scarred, rubbed, and even uprooted, by those borne on the current of the swollen stream. A toilsome walk brought us to the foot of the slide which lay directly in the bed of the stream. This side of the mountain is quite steep, and in outline regularly triangular. Its height is about four thousand two hundred feet.

The slide commences forty rods from its summit, and a little to one side of the highest point. At the outset it is very narrow, being not more than a rod wide; a narrow tongue runs above this, however, for a short distance. For fifty or sixty rods the increase in width is very gradual. The inclination is very steep, appearing almost perpendicular and probably not less than fifty to sixty degrees. For the next hundred rods the width increases more rapidly. A hundred and thirty rods from the top the widest part is reached. Here the sides bend gradually outward and the width is twenty-five to thirty rods. From this point the sides begin slowly to approach each other, and thirty-six rods below, a hundred and fifty-six from the top, the width is nearly seventeen rods. The course from the top to this point is in a direct line, but here a curve toward the northwest begins and ends eighty rods below, nearly at a right angle with the main axis. The whole length is nearly two hundred and forty rods, and the outline is fusiform, with the lower end curved to one side. Directly across the line of the main axis a few rods from the foot of the mountain runs a high ridge. Instead of striking this, as would have been expected, the slide begins to turn nearly a hundred rods above, and when within twenty rods is almost parallel with it. There seems to be no reason why sand, rocks and débris of all sorts should not have been thrown against this ridge; indeed there is every reason why they should have been. Yet the space between it and the slide is singularly free from such material. There is undoubted evidence that one or more watercourses ran down the mountain before the slide, and probably did much to cause it. These streams, which form part of the source of Mad river, must have been very inconsiderable, and yet the mass of rock and sand seems to have been guided by them in its downward course. It appears incredible that so great a mass moving with power and velocity enough to snap off hundreds of great trees, crushing many of them to splinters, and piling up such heaps of débris, could be directed by such small watercourses, but the facts indicate it.

There has for a long time, been the track of a former slide down a part of the surface covered by the more recent one, but it was very small. Contrary to our expectations the side of the mountain over which the slide passed, was not bare rock stripped of surface material. Only in two places, both small in extent, was the rock foundation of the mountain exposed. One of these was at the top where the slide seemed to have started from a ledge, the other was a little less than half-way down, and reached entirely across the track of the slide. With these exceptions the whole surface was covered with a loose, coarse sand or gravel, consisting entirely of comminuted rock, increasing in depth from top to bottom and very loosely compacted. The thickness of this loose material was shown along the sides of several small streams that were running down the slide, which, at the time of our visit, the 20th of October, had cut entirely through it, and ran over the solid rock beneath. Near the top the ground was moist but there were no streams; these began twenty or thirty rods farther down. At the top of the slide, the surface sand was only a few inches deep; below the second exposure of rock it was between one and two feet; at the widest part, a hundred and thirty rods from the top, it was from six to eight feet; a hundred and fifty rods, it was nine to ten feet, and at the bottom fifteen to twenty-five, and in some places, even thirty feet deep. At this point the slide seemed to have suddenly stopped, for there was no gradual diminution in thickness below it.

How much of this coarse gravelly sand originated with the slide, being ground by it from larger rocks; and how much existed before as surface soil disintegrated from the solid rock, I could not estimate. The sand was pure syenite and contained no trace that I could find, of any vegetable mold. From an examination of the banks of Mad river below, and of the soil by the side of the slide, I am convinced that the greater part was produced by the disintegration and falling to pieces of the mountain's rock, and so existed before the slide, and was carried along and heaped up by it. The mountain is, so far as I could learn, wholly composed of light gray, rather coarse syenite, which appeared to disintegrate very readily, as I saw large masses that could easily be pulverized. A mile below the slide there were extensive layers of black hornblendic rock, and in one place the syenite was crossed by trap dikes, from an inch to a foot in thickness. Some of these dikes forked several times, others crossed each other in the form of a letter X, and some varied greatly in thickness along their course. A few broken crystals of rose-purple quartz, an inch or more in diameter, were found among the débris. But the only rock in place along the course of the slide was the syenite.

Scattered all over the surface of this loose, sandy material, were masses of syenite, of various sizes though none were very large. These were angular, and appeared to have been recently broken. They were undoubtedly fragments of large masses broken by the slide. Besides these, there were a few well worn boulders of syenite, quartz, and hornblende rock, some of which were near the top.

All the trees that had stood on the ground now occupied by the débris of the slide, were carried away or buried up, only a very few bare logs remaining in sight.

Along the sides of the slide the forest was full of uprooted, bruised, and broken trees.

The upper part of the slide was much more rugged and covered with a greater mass of broken rocks than the lower. Over the widest portion there were few rocks on the surface, which was smooth and level as if rolled. Below this it was rougher but not as much so as above.

The appearance of the surface was the same in all parts. Its color was a light yellowish brown, and at a little distance it closely resembled a field lately ploughed and harrowed.

It is the contrast of light color with the dark green of the spruce forest around it that causes the slide to be so distinctly visible at long distances. As is stated above, the upper portion of the slide is very steep, but after the first fifty rods the angle of inclination is less, and just above the widest part it is not more than twenty-five degrees. Below it is not more than fifteen degrees.

Art. XX.—*On the Silver Mines of Santa Eulalia, State of Chihuahua, Mexico*; by James P. Kimball, Ph.D.

The silver mines of Santa Eulalia were among the earliest mineral discoveries of the Spaniards in Northern Mexico. Don Jesus Inocente Irigoyen of Cusihuiriachic, a good antiquarian authority, states that the year of discovery was 1591. The only available official register of their performance, however, goes back no further than 1705, but mentions their discovery in 1703—twelve years after the city of Chihuahua was founded, according to the date given by Dr. Wislizenus. From 1705 to 1737, they produced 6,583,500 marcs, or an average of 1,938,903 dollars of silver per annum. Up to 1791, during a period of eighty-six years, their acknowledged production of silver, of which the *quinto*, or king's fifth, was paid to the royal exchequer, was 11,903,126 marcs, or nearly *one hundred and twelve millions of dollars*, and their entire production from one-fifth to one-third more. At this period the district had a population of 6000, and supported sixty-three reduction establishments with one hundred and eighty-eight smelting furnaces of the type known as the Mexican *horno*, and sixty-five cupelling furnaces; while a number of similar establishments in the city of Chihuahua were also kept running on ores from this district. The depredations of the savages, which until comparatively quite recently have always seriously interfered with industrial pursuits in Northern Mexico, became so grievous during the last five years of the past century that the district was gradually abandoned.* Indian hostilities were soon followed by political troubles, including the war with Spain and the proscription of the Spaniards. During the present century, operations at the hands of the Mexicans have never been fully resumed. Yet shallow workings have continued to furnish ores to a small number of furnaces, which to a considerable extent have also made use of the débris of former operations. At present ten blast furnaces, each of a capacity of 2500 to 3000 lbs. of ore per day, are in operation, their small supply of ore being drawn from the older as well as the newer mines. The fresh ore from the mines as charged to the furnace, is eked out with the settlings of the old slag heaps, and coarse refuse from old workings, extracted from the dry bed of the creek which in time of rain courses through the mining village of Santa Eulalia. As in old times, for the sake of mutual protection, the reduction works of the district are still all collected here, along with the dwellings of the miners and smelters, who number with their families some 700. Recollections with the old, and traditions with the young, still fill the minds of the dwellers in this narrow valley with dread of the Apache, who even now is occasionally found lurking among these mountains, and of whose hiding all have been taught to be wary when moving about alone.

The village of Santa Eulalia is fifteen miles east of the city of Chihuahua, across the expansive champaign valley of Tabalopa. This city, the capital and social center of the state of the same name, and containing some 20,000 inhabitants, attained its importance mainly through the silver industry of Santa Eulalia, in the period of whose prosperity it had a population of 70,000. Chihuahua afforded—what have ever been lacking at Sta. Eulalia—water and space for the dressing and reduction of ores; and to the city therefore was brought and smelted a large portion of them. Immense heaps of slag, twenty in number, on the outskirts, attest the extent of work done there during the last century, while the imposing, and in some respects admirable, cathedral of the city is a monument to the mines of Santa Eulalia, it having been built out of a fund raised by the tax of one real per marc of silver coined,

* Manuscripts and certificates in No. 65, folio 26, state archives. See also Ward's Mexico, 1st edit., vol. ii, p. 129, (2d edit., i, p. 454).

and which, continued for sixty-two years, ending in 1789, amounted to 800,000 dollars.*

The Sta. Eulalia mountains are a portion of a long range trending N.E.—S.W., one of a system of parallel ranges, which, separated by champaign valleys or valley-plains, characterize the topography of the sloping margin of the Grand Sierras, and as much at least of the state of Chihuahua as lies north of the 28th parallel, and east of Concepcion—beyond which limits my experience does not extend. The range lies between the broad and fertile valley of the Conchos on the east, and the narrower valley-plain of Tabalopa on the west. Access to the village and mines of Sta. Eulalia is from the latter. The village lies two-and-a-half miles from the plain up the mountain stream of the same name, at the foot of the higher hills, in which, at distances of two to five miles, the mines are situated, and which are crossed only by bridle-paths.† The mining ground is embraced within the area of an uplift of the Cretaceous fossiliferous limestone, imparting toward the center of it gentle quaquaversal dips. This is a prolongation of the narrow continuous elevation of this formation, reaching to the Rio Grande in an axis parallel to the Conchos river, and a part of the same formation which in Texas comes to the surface in the Rio Grande basin, at least, between the 28th and 31st parallels, except in mountainous localities, or in the case of stratigraphical depressions, where an upper and metamorphosed member of the same formation (a porphyritic quartzite) known in Mexico as *cantera*, caps the summits.‡ In Mexico, under similar conditions of superposition of the latter, the

* State archives. Ward erroneously states this tax to have been collected during nine years pending the last *bonanza*, ii, p. 581. (2nd edit., p. 305).

Accustomed, as of late, we have become to the far higher returns of not larger groups of silver mines, it is easy to pass over the full significance of the comparatively low figures of early operations in northern Mexico, unless we are mindful that it is to the availableness of mechanical appliances, that our great production of silver is more to be ascribed than to the number or superiority of recent discoveries. What account of the Comstock lode by this time should we have were its mines, as in the case of those of northern Mexico during the period of their activity, without other than the rudest iron or steel implements, without powder, except in rare cases of a foreign stinted supply, with only the *adobe horno* for smelting, and the little *cazo* for amalgamation; and continually harrassed by Indians? Although supplies are no longer quite out of reach, the mines to-day are worse off than during the last century, for most of them have reached a point where have become necessary mechanical appliances, with which the Mexicans are entirely unacquainted. They continue to suffer the want of what *adobe*, raw-hide, and wood will not supply, following the practice of the Spaniards, which in their hands has rather retrograded than advanced. The silver industry of Chihuahua at present amounts to little more than cleaning up the rubbish of former workings.

† For a popular and graphic account of this picturesque mining district, see an article by Gen Lew. Wallace in Harper's Monthly, Nov., 1867.

‡ See notes on the Geology of Western Texas and Chihuahua, by the writer, this Jour., xlviii, p. 378.

Cretaceous fossiliferous limestone, with local lithological differences, is the prevailing formation of the Rio Grande and Conchos basins, where, as seems likewise to be the case in Texas, within the development of the cantera it sustains throughout a metalliferous character. The mineral deposits of Sierra Rica, Cuchillo Parado, the Chupaderos, and the Chorreras in Chihuahua are all contained in it. In the Santa Eulalia mountains is its most westerly development in any great prominence above the valley plains, though seventy-five miles still further west, a limestone is said to form the low base of the Sierra de Magistral, where it is likewise metalliferous, and where, going west, it is last seen. In the Santa Eulalia mountains, the same as in other localities named, the *cantera* caps the higher elevations. This name is applied in Northern Mexico to the bleached portion of an essentially alumino-siliceous rock, generally more or less metamorphosed and ferruginous, and occurring in a great variety of colors.* As elsewhere explained, it is to the disintegration of this rock that the accumulation of soil in the valleys is due, as well as their peculiar conformation.†

Allowing for erosion, the mines of Santa Eulalia may strictly be said to be grouped in a single great boss of the Cretaceous limestone strata, gullied or scored by water-courses which impart to all portions of it a rugged and precipitous configuration. There, as elsewhere throughout the development of the fossil iferous limestone, the water-courses have cut bold, almost perpendicular, escarpments in which the stratification is very plainly marked. In this district the dips are from 5° to 15°, and from a point near the Vieja mine are quaquaversal. The ravine, Arroyo de Dolores, which takes its name from the old mine of Dolores, at its head, has been cut through the crest of the limestone uplift, and thus exhibits in steep mural escarpments a partial thickness of the formation of 400 to 500 feet. Its true thickness, however, has never been revealed. The oldest and most extensive mines are in this ravine, including the deep ones of Dolores, Vieja, Aguada, and the shallow or cavernous workings of Parcionera, San José and San Matias. The distance of Arroyo de Dolores from the village is some three miles, horizontal, from four to five topographical.

As the limestone uplift or boss expires, the summit cantera, a few remnants of which cap the limestone hills, sets in, and within a couple of miles, becomes the main formation, and forms the body of the range. No limestone appears in the Puerto de Dolores, seven miles to the north, where the San Diego and Chihuahua road crosses the Sta. Eulalia range; and in the village of Sta. Eulalia, it has already declined below the surface. The overlying cantera presents a greater development

* This Journal, xcviii, p. 380. † Ibid, p. 381.

in the surrounding hills, which rise to the height of some 800 feet above the plain.

A curious lithological phenomenon, though in a less conspicuous way not uncommon in other localities which I visited in Chihuahua, is a formation of conglomerate which is found on all the slopes of the district, and which incases the lower and middle portions of the hills like a shell.* This has evidently been formed by carbonated calcareo-magnesian infiltrations, springing from the summit cantera; and, penetrating the fine and coarse detritus of the surface alike, have cemented it, and thus produced all the gradations from a fine friable sandstone to a coarse breccia. The village rests upon it. In the main street it is distinctly bedded, and cleaved by joints. Nowhere is it found entering into the interior structure of the hills, and no traces of it are found in steep places. Yet cursory observation might dispose the traveler to assume the main body of the mountains to be made up of this formation.

The mineral deposits of Santa Eulalia are unique. The only instance of a vein formation brought to my notice in the region is in the Santo Domingo mine. All the rest of the deposits are more or less irregular, and in a variety of modes of occurrence, are contained in the nearly horizontal fossiliferous strata (Cretaceous). All the strata above water level are exceedingly cavernous. In nearly all of the workings, caves, entirely shut off from the surface have been encountered. Some of these are of enormous size. The great cave of the Parcionera and San José mines, is said to be large enough to hold the cathedral of Chihuahua. Though unable to explore its height, or to illumine its roof, I am disposed to believe this. Drusy cavities or vugs of all sizes, are the smaller exhibitions of the same prevailing cavernous character. These latter yield excellent pockets of ore. Rich *bonanzas* have been got from chambers in the walls of the large caves. The ores which are mainly the chlorid and sulphids of silver, argentiferous galena and salts of lead, together with, (though of rarer occurrence,) the chloro-bromid (embolite) and iodid (iodyrite) of silver, are very ferruginous, to which circumstance they owe their friable character, and also, to a considerable degree, the spaces in which they have been deposited. Courses of ore are always marked by ferruginous stains, which, properly considered, are segregations of mineral matter, sometimes following cleavages and joints, and sometimes planes of bedding, and, again, sometimes reticulating solid beds, and in all these modes of occurrence, without order or defined limits. A bed, or a number of beds, of the limestone, in places may be thoroughly webbed with such segregations of so decided a character as to

* This Jour., xlviii, p. 382.

impart a concretionary appearance, or, as if limestone breccia were cemented by ferruginous ore. In such places the beds, are *not* brecciated, but thus strikingly indicate the energy of disintegrating and segregating action under the decomposition or oxydation of iron salts (probably proto-carbonate) originally contained in the limestone, together with diffused salts of silver. These ferruginous portions always afford good mining ground. As some of them are very extensive, and as their distribution is irregular, their excavation results in large and rambling chambers, generally ranging through a number of the heavy beds of limestone. Such chambers are often continuous with natural caverns, together forming underground spaces scarcely less imposing than the most noted caves that excite the wonder of tourists.

The mines of Santa Eulalia are scattered all over the great limestone uplift, and along the deep ravines which have scored it. All are comprised within an area of some five square miles. In the hillsides they consist mostly of horizontal workings, and occupy different strata from top to bottom. Shafts and deep workings, which are few and ancient, are located both in the hills and ravines. Accessibility of the mines is determined by the topographical configuration of the mining ground, the primary form of which, before modified by erosion, it is important to keep in view. As they are reached from the village by three different trails, I will describe them in as many separate groups, as follows: the *Santo Domingo group*, comprising the workings in the same cañon as the Santo Domingo mine, and of which this mine is the principal; the *Dolores group*, or those in the cañon, at the head of which is the old Dolores shaft; and the *Guadalupe group*, comprising the workings on the summit and S. W. flank of the limestone ridge, which forms the divide between the Dolores Cañon on the northwest, and on the southeast—the waters of the *arroyo* in which is the village of Santa Eulalia.

Santo Domingo Group.—The Santo Domingo and neighboring mines are two miles north of the village, up near the head of a deep ravine, in both sides of which, at different elevations, they have their entrances. As this locality is about one-and-a-half miles to the southeast of the axis of the boss, the dip of the formation is seen rapidly declining in the ravine toward its mouth, and the overlying cantera is thus brought down so as to form the body of the hills. The limestone altogether disappears from above the bed of the ravine within a few hundred yards south of the Santo Domingo mine, where the cantera sets in and forms the surface. The town is really on the horizon of this formation, though the surface is immediately overspread by the cemented rubble above described. The hills on either side of the defile in which the village is situated, rising as they do some 700 feet above it, are both topographically and stratigraphically the highest elevations in the district. They are made up wholly of cantera distinctly and nearly horizontally stratified, and in different zones weathering with a variety of colors. They have mesa tops, and present to the broad valley-plain of Tabalopa bold escarpments flanked by low foot-hills.

The *Santo Domingo*, old and present, are deep workings entering the limestone boss on the west side of the ravine. The old mine, now abandoned and dismantled, consisted of a shaft located so high on the hillside that it must have pierced one hundred feet of cantera before striking the limestone. The present mine is some 500 yards further up the ravine, and, at an elevation above its bottom of some 120 feet, goes down in a bed of fossiliferous limestone some 30 feet from the top of the formation, the division being plainly indicated by a ledge of cantera above the entrance of the mine. Its depth is about 400 feet. This is reached by an irregular descent, the only thoroughfare, in which passage is laboriously effected partly by means of ladders, and partly by footholds in the rock. This main-way occupies a vertical crevice in the limestone, or a series of cavernous partings more or less filled out with workable ores. The widest portions are some 12 feet, the most contracted, not more than six inches. Many of the former are of the nature of drusy cavities lined with quartz and gypsum. The narrower portions have generally yielded paying ore of a decomposed and ferruginous character. The vertical crevice, which has been followed westerly into the hill has been pretty thoroughly wrought. The most extensive workings, however, follow rich partings between planes in the limestone beds, thus giving rise to lateral excavations opening into the main-way. Rich pockets of galena are found both in the crevice and in the horizontal deposits, and these seem to be increasing in depth. Indeed it is chiefly for galena and other plumbiferous ores (*plomosos*), that this mine is at present wrought; and it appears that its ores of all grades (*ayudas*) have always been prized less for their argentiferous qualities, than for the property of facilitating the smelting of the more refactory ores (*resecos*) of the district.*

* Although over 300 feet below the bed of the ravine, which is dry except in the rainy season, there is no water, or even sensible moisture in the bottom of the mine; and though the deepest mine at present wrought in the region, it is, like all the others, without mechanical appliances of any sort. The ore is spalled underground and brought to the surface on the backs of men and boys whose burdens vary from 100 to 125 lbs., and who make during the day five trips to the bottom. The mine is so excessively warm and badly ventilated as to be almost suffocating; while its passages are so worn and polished by the hands and feet of the miners as to afford the most precarious footing. The carriers (*tenateros*) are surprisingly muscular, nimble and sure of foot, running with swiftness up and down the single

The other workings of this group are on the east side, and further toward the head of the ravine, occupying different beds in the limestone and pursuing productive courses of ore. The principal are *Chiquihuite*, *Rosario*, *Gertrudis* and *S. Lazaro*.

DOLORES GROUP.—The cañon of Dolores is a deep gorge cutting almost perpendicularly the axis of the limestone uplift or boss. The cliffs thus formed, expose on either side a perfect section of bare limestone strata. Its course is very nearly westward, and its head opposite and very near that of the Santo Domingo arroyo. Together the two water-courses describe a triangle, and as they border the mining area impart this shape to it. A lofty ridge capped with the summit cantera divides the two waters. Owing to the comparatively rapid declination of the limestone strata in this direction, the workings toward the head of the cañon are by means of shafts going down just above its dry bed. They are the Tiro Dolores, present Dolores, the "Gauo" (Aguado) and the Vieja shaft.

The *Tiro Dolores* is a vertical shaft starting in the cemented rubble, but soon striking the fossiliferous limestone which, from 200 to 300 yds. below, is uncovered in the bed of the cañon. The shaft is 327 ft. vertical—at which depth a slanting passage, now flooded with rain-water, carries it some 100 feet deeper.

The *Aguado*, like the Dolores, is now inaccessible. It is an irregular sinking of about the same age and depth as the latter, and communicates with it by deep workings. Its mouth is near the top of the limestone formation.

The *Dolores*, present working, is a sinking of the same description as the Aguado, with the lower workings of which, and thereby with those of the older Dolores, it connects. The upper and more accessible workings are still wrought in a small way for plumbiferous ores. The *Vieja*, some 200 yards still further down the arroyo is also an irregular sinking carried to the depth of about 165 ft. It still affords desirable silver ores.

All these mines were formerly diligently wrought—the shafts by means of horse-whims. From a watch-tower on the highest point overlooking the whole district, timely warning of the approach of the savages could be given. Ruins of stone dwellings built strong for defense, indicate a former settled establishment in the bottom of the defile, which, as in the case of all the others in the region, contains water only during rains. The water in the mines appears to have got in from the surface, no percolation being sensible even in the deepest.

In the immediate vicinity of these old workings, near the

notched stem of a ladder, and the shelving, slippery rocks in lieu of steps, but laboring for breath, and their bare bodies bathed in perspiration. No laborers in the world have a more arduous task. The cost of raising the ore in this manner is 25 cents per 350 lbs. This could be greatly reduced, and the mine improved by an opening from the ravine.

head of the arroyo, the dip of the limestone beds to the southeast is near 45°. The vertical axis of the boss is in the eroded neighborhood of the Vieja, at the confluence of another arroyo from the southwest. From this point in every other direction the dips (quaquaversal) are gentle, coming down gradually to not more than five degrees. But the steeper dips toward the outside of the limestone boss have brought up a great thickness of this formation (400 ft.) above the arroyo, and thus west of the Vieja the same strata are above its bed, as could only be entered by shafts east of this point. This is an explanation of the fact that below the Vieja all the workings are above the bed of the ravine, their openings being in the bluffs. These workings are all approximately horizontal: that is, they follow the stratification which on either side being slightly inclined *from* the ravine, gives them all something of a descent *into* the body of the hills.

The *San José* enters the south bluff a quarter of a mile below the Vieja, some 30 ft. above the bed of the arroyo. Its workings extend to several beds, the excavation of which has caused great chambers, while a number of natural caves also have been opened. The ores here are mainly diffused through the limestone strata in ferruginous and the more decomposed portions. They are also found in courses leading from stratum to stratum, but never in the form of a vein.

The *Parcionera* opens near the San José some 70 feet higher up the bluff—its workings, however, descending so as to connect with those of the latter, and thus excavating several beds. It may be described as a series of caverns, both natural and artificial, the largest in the district. It is here that is to be seen the immense one already mentioned. The openings extend about 500 yds. into the hill, in which distance they fall some 150 ft. The pursuit of courses of ore whither they might lead, has caused very irregular passages. The ores of the mine are highly prized, and at the time of my visit were being extracted by twenty miners for the supply of the furnaces of Don Emanuel Escobar. The ores then coming out were plumbiferous. Their mode of deposit does not differ from that of the San José ores.

The *San Matias* is in the north bluff, directly opposite to the San José and Parcionera, and going in on the same level. It is one of the more cavernous, as well as one of the largest and oldest, mines in the district, having been wrought southeastward so as to connect by descending passages with the workings of the Vieja, a quarter of a mile off. It is still wrought by Mateos & Co. Its ores are excessively ferruginous (*colorados*), their color being that of red hematite. According to the owner they are now yielding 12 ounces to the carga ($103 to the ton.)

Several openings in the north bluff have been made at higher levels. One, the *Cuartillera*, is at the height of some 300 feet above the bottom of the cañon. It furnishes a non-ferruginous ore of a drab color.

GUADALUPE GROUP.—It is convenient thus to designate the numerous workings in the same hill with the Parcionera, situated, topographically speaking, some above these mines, and some on the opposite north and west sides, wherever the surface is not too steep to afford easy access.

The *Guadalupe* mine is directly over the Parcionera and San José, and opens from the plateau which marks the top of the limestone formation. Its workings progress southeasterly, descending through several very ferruginous beds in which silver ores seem to be concentrated in "pockets"—the average ferruginous courses being filled with segregated quartz, and generally barren. A drusy cavity is said to have been struck here in 1865 which gave in one day sulphids of silver worth $5000; and five months afterwards another, yielding $1200.

The *Aragon* is a similar working in still higher limestone strata, and very near the junction of this formation with the cantera, here a buff, porphyroidal quartzite, a fine outlier of which rises some 150 ft. above the limestone plateau. Both this mine and the Guadalupe steadily yield plumbiferous ores, carrying, mostly in an invisible form, chlorid, bromid and sulphids of silver.

The other mines of this group are all on the left flank of the limestone ridge. They are the Santa Rita, San Francisco, Purisima, Negrita Grande, Negrita Chiquita, and the Carmen.

The *Santa Rita*, one of the oldest and more reputable mines, is a shelving excavation, starting in fossiliferous limestone, some 350 ft. above the bed of the Dolores arroyo. A large burrow of ferruginous material indicates the extent of former workings. The main opening is said to be asphyxiated, and is now closed, though containing, according to all accounts, ores running as high as four marcs to the carga ($250 to the ton).

The *Purisima*, occupies nearly the same level as the Santa Rita, going down some 60 ft. in heavy bedded limestone, fossiliferous at the surface. The fossils, as usual in this locality, are a coral, *Radiolites*, and fragmentary *Pecten* and *Inoceramus*. The mine, though now vacant, was worked three years ago, and is said to have proved satisfactory.

The *San Francisco* is a sloping excavation in the hillside, and some 100 ft. lower in the limestone than the Santa Rita. The workable portions of the limestone beds closely resemble those of the workings in the Dolores arroyo. The mine is now supplying highly prized ores to the Chihuahua Company's hacienda.

The *Negrita Grande* is an old, now inaccessible, shaft, more than 250 ft. deep, which depth about corresponds to the level of the arroyo immediately below the mouth of the mine, and from which it would be practicable to reach its workings. The shaft was formerly worked by horse-whims (*malacates*)—probably by the distinguished Bustamente who is reputed to have had a *bonanza* from it of $60,000, said to have been in the form of concentrated chlorid of silver.

The *Negrita Chiquita* is a newer open working, now operated by Don Jesus Mateos, and occupying strata but a little lower than the mouth of the shaft of the *Negrita Grande.* The *Carmen* occupies beds somewhat higher, and is a similar cavernous excavation.

It will be understood that notwithstanding wide differences in topographical level, all the workings above mentioned are embraced within the same set of beds whose combined thickness does not exceed 450 ft.; that the shaft workings at the head of Arroyo de Dolores, the mines of the Santo Domingo arroyo, and the workings on the top of the plateau forming the surface of the limestone uplift, *all have their entrance at about the same stratigraphical horizon; that is, near the top of the limestone.* And it is to be borne in mind that stratigraphically the lowest workings are *not* those which topographically are the lowest, but the San José and San Matias instead of the Dolores, Vieja and the Aguado.

Notwithstanding the number and size of the excavations in the mining ground of Sta. Eulalia, and the large returns which these have afforded, its future prospects seem scarcely impaired by the achievements of the past. By the modern scale of mineral industry, these might pass for only a thorough exploration—in its assurances worth all that it has yielded. The location of the mines has been determined by the accidents of the surface rather than by promising outcrops—a foothold upon the surface seeming to have been all that was necessary. Besides the great amount of unbroken ground left in and amidst the established mines, a large body of the limestone strata remains untouched, especially to the north of the Dolores arroyo, where the inner ends of the workings, proceeding from the bluff on that side, show no deterioration or diminution of the ores. It is not venturing too much to predict that the past record of Sta. Eulalia will be far surpassed at some future time by its development prosecuted by an enlightened practice.

Yield.—Extracted according to the judgment of the miners who are very expert in the detection of familiar ores, the ores after being spalled, run from 4 to 6 oz. to the carga ($34·46 to $51.60 per ton of 2000 lbs.) Four-ounce ores are abundant in all of the mines, but scarcely pay for working by the present smelting practice. By care in selection, this grade is easily brought up to five and six ounces to the carga. This is the lowest working yield of all the smelting operations—the average being something above this. Don Jesus Mateos, one of the most experienced operators in the district, by using a mixture of the 12 oz. ores from the San Matias and 6 oz. ores of the San José, obtains never less than 6 oz. to the carga, generally as high as 8 oz., and sometimes 9 and even 10 oz.

Cost of ore.—The cost of ore delivered at the mouth of the mine varies according to the expense of raising. At the Parcionera, which may be taken as the type of horizontal or sloping workings, this cost, which includes all mining expenses, is stated at $1.50 per carga. At the Santo Domingo, the cost is greater on account of the laborious raising. The ores are delivered at the furnace for 20 to 37½ cents per carga, the donkey-load being one carga (300 lbs.)

Reduction.—The furnace employed in the district is the common Mexican *adobe horno*, a blast-furnace 47 inches high, 18 in. wide at the top, slightly tapering toward the bottom, and 16 in. across. The blast is supplied by hand bellows, the nozzle of which is in the back, 8 in. from the bottom. In the better constructed establishment of the Chihuahua Co. the bellows are set in motion by mules. The charge of the furnace varies according to the notion of the smelter as to the requirements of the different ores. Mateos uses 75 lbs. of spalled ore to 20 lbs. of litharge, and 12 to 25 lbs. of old slag (*grasa*) by way of flux. The charge of litharge varies with the ore. Plumbiferous ores, like those of Santo Domingo, Santa Gertrudis, Dolores and San Antonio, give an excess of litharge, and hence are in especial favor for mixture; while the excess of litharge obtained is sold out of the district at the rate of 8 to 16 dollars per carga ($2.67½ to 5.32½ per cwt.) The cupellation is done in the ordinary *adobe vaso*, one serving three blast furnaces, or treating 20 cargas of argentiferous lead per week.

Fuel.—The question of fuel is one of paramount importance to the industry of the district. The *mesquite* root is the only indigenous fuel of the immediate section of country, forest trees being entirely unknown east of the humid belt, 50 miles to the west of Sta. Eulalia, except the cotton wood (*alamo*) which is cultivated for shade. Yet nothing could excel this root as a fuel, either as it comes from the ground, or after conversion into charcoal. A single shrub generally gives near a cord of heavy root. In the neighborhood of Sta. Eulalia, the *mesquite* has long been exhausted by the draft upon it from there, and from the city of Chihuahua. Oak charcoal is brought 30 leagues to Sta. Eulalia from Mapula, and sold at the rate of 75 cents to one dollar per quintal (100 lbs.)—the lower price prevailing whenever the roads are favorable. Oak wood is likewise brought thither, and sold at the rate of one dollar (copper) per carga (80 sticks, 28 by 4 in.). The same prices prevail in the city of Chihuahua. Mesquite charcoal from the east side of the Sta. Eulàlia Mts. is delivered at the village for $1 to $1.50 (copper) per quintal. These prices, already high, would doubtless steadily advance under a larger and more pressing demand, such as would be created by an extensive smelting industry depending upon a *certain* supply and *limited* price of fuel, without control over either.*

With a cheaper mode of reduction, the cost of production would be very considerably lessened by rendering available ores which, though cheaply and largely broken, are now rejected —ores yielding as high as $34 to the ton. This condition, rather than the introduction of mechanical appliances, would necessarily bring this cost below the cost of extraction of silver ores from expensive workings in Nevada, though now far exceeding that of most of the deep mines of the Comstock lode. But the cost of reduction is even more excessive and out of proportion to the value of the ores. Though the Mexican smelting practice is attended with a smaller loss of silver, the fact that Nevada ores returning no more than $15 per ton can be worked by amalgamation with some profit, more than offsets the loss of 20 to 25 per cent to which all are subjected, as a large and regular business generally depends upon the availableness of the ores of low grade—always predominating in extensive deposits. Yet the Mexican furnace by no means extracts the whole of the silver as may be seen by picking up from any ancient or fresh slag heap fragments containing numerous globules of argentif-

* Expressing in familiar units the above rates imparted to me by Don Jesus Mateos, we have in a form for comparison with working results elsewhere obtained by different modes of reduction the following exhibit:

Cost of Production.

Cost of ore at mouth of mine, per ton, at $1.50 per carga,		$10.00.	
Transportation to furnace, " " 0·37½ "		2 62½.	12.62½

Cost of Reduction.

Charcoal in blast furnace, per ton of ore, at $1 per quintal,		$10.62½	
Wood " *vaso*, cupelling, " " " $1 per carga,		2·66⅔	
2 Smelters at $1. per diem, 1 Refiner at 1. " 6 Helpers at 0.37½ "	Labor,	4.92	
Litharge, repairs, etc.,		1.00	19.21⅙
Total cost of production and reduction,			$31.84

Having adopted the mean of variable rates, no allowance is made for the discount of copper currency (at the time of my visit, in the winter of 1869—33⅓ per cent; but now much greater) in which are stated the prices of fuel, especially as the above exhibit bears out the representation of Don Jesus; namely—that in the failure of the 50 cargas of ore smelted weekly by one furnace to yield a total of thirty marcs of silver, that is (taxes paid) $32 per ton, loss is incurred.

erous lead, and otherwise indicating imperfect reduction. Fuel is far more costly at Virginia, Neveda, than anywhere in Chihuahua, but this difference follows from the higher price of labor there—the supply of fuel really being greater than at Santa Eulalia.*

Thus will be seen the mistake of treating the ores of Santa Eulalia by a practice which is so costly as to render unavailable the great bulk of them, and to absorb almost the whole value of even the choice ores in their reduction, when by a cheaper practice the whole run of the ores could be treated with profit, and the industry improved and expanded in all respects. I allude to amalgamation as practiced in Mexico itself, and which the climate, labor and facilities of the country especially favor. In 1846, it was estimated by Mr. John Phillips, seven-eighths of the silver produced in Mexico was obtained by amalgamation.

The lack of surface for *patios* at Sta. Eulalia, together with the scantiness of water, are circumstances sufficient to account for the prevalence there of smelting, notwithstanding the ores are of a nature to yield readily to patio amalgamation. That these difficulties have never been surmounted is to be ascribed to the isolated condition of this section of country, and its lack of facilities for extralimitary supplies. In the last century, during the period of its prosperity, as I learn from a manuscript in the state archives, amalgamation both by *patio* and *cazo*, was carried on at Sta. Eulalia and Chihuahua to the extent of keeping in operation in the two places 72 drag-mills (*tahones*), and 6 stamp-mills (*morteros de agua y caballerias*). The reduction works, just erected, of the new Chihuahua Co. have not in the least departed from ancient models. Nor would a change of practice be warranted by anything short of an extensive undertaking. In view of the scarcity of water and fuel at Santa Eulalia, it must be seen that present operations without modification can scarcely be extended beyond their present scope. As long as they are thus limited, they are favored by the choice of ores, and by cheap labor. By dispensing with mechanical appliances for dressing ores any considerable outlay is avoided.

The silver deposits of Santa Eulalia, however, are so superior and extensive as to warrant their extraction and reduction on a

* Notwithstanding the rates of labor in Nevada are more than treble those of Santa Eulalia, the ores of the Comstock lode are extracted for a half to a third less, and reduced for less than a half cheaper—their average yield ranging in different mines from $28 to $43. To properly contrast the wide difference between the economical conditions of the industry taken as a whole in the two localities of Sta. Eulalia and Virginia City, it is necessary to consider that of the latter as involving an immense outlay for milling and deep mining, altogether beyond the requirements of the former locality. It is also obvious that a high cost of fuel would, the same as at Santa Eulalia, preclude the practicability of working by smelting any but *selected* ores, and thus confine the Comstock industry within comparatively narrow limits.

large scale. This will be practicable by having recourse to the facilities afforded by one or both of the two plains on either side of the Sta. Eulalia mountains.

West of the mountains, superior facilities for the dressing of ores, and for patios, are to be had at Tabalopa on the Sacramento river, at the distance of some eight miles from the mouth of the Arroyo Dolores. Ores could be delivered at this point by wagon at near the same rate that they are now freighted on mules over the mountains to Santa Eulalia. This way out to the plain would be by the ravine, and thence the whole way to Tabalopa by a down grade.

Having extended my observations but a little way east of this gorge, I am not prepared to determine the question of an exit on that side of the Sta. Eulalia range. Should it be found practicable to cheaply deliver ores in the Conchos valley, this side would, on the whole, present superior conditions for reduction works, provided a good water supply can be had, which is probable, as the plain is already thoroughly irrigated. Fuel (mesquite) is far more abundant here than on the Chihuahua side, and the position is nearer by two days to all supplies drawn from Texas.

New York, Jan. 1, 1870.

ART. XXI.—*Machinery and Processes of the Industrial Arts, and Apparatus of the Exact Sciences;* by FREDERICK A. P. BARNARD, LL.D., United States Commissioner to the Paris Universal Exposition.

IF the imperial decrees of June, 1865 and subsequent dates, which gave origin to the Paris Exposition that opened on the first of April, 1867, were grand and comprehensive in their scope and intention, they were equally illustrious in the success and completeness of their execution. More than fifty thousand exhibitors brought together on that occasion several millions of objects, all different and all deserving attention. These were gathered from some forty nations and countries, covering the entire civilization of the globe. Taken together they formed a representation of the art, the industry and the inventions of mankind, and of every ideal yet realized for the comfort, the elegance, the operative power, and the progress of the human race. From the material to the implement the completed structure or the machine; from the staple to the fabric; from the massive and gigantic—the products of Cyclopean forges or Titanic engines—down to the infant's toy and the gossamer vestment; from the ponderous gearing to the tiny time-piece all were spread out, an accumulation of series upon series, and every series showing an almost complete and continuous gradation.

The field of the Exposition was the parade ground, or Champ de Mars, easy of access, and supplemented by annexing the island of Billancourt in the Seine, together comprehending an area in excess, by a few acres, of one-fourth of a square mile. Spacious grounds outside the building, or *palace* as it was called, but without much very palatial in its aspect or construction, were allotted to 'structures that ranged from the nomadic hut of an Esquimaux to the gilded palace of the Sultan,' and to such living, or agricultural, or other objects and groups, as could not suitably be admitted within. In deference, we suppose, to French propensities, the number of groups was just ten; but, by a marvellous aberration, the number of subdivisions or classes was but ninety-five. Seven of these so classified groups were arranged in seven oval galleries, one story high, successively surrounding one another, and divided systematically into commodious apartments, the entire assemblage of which comprised an area of forty acres and a circuit of almost a mile. In the center was a pavilion holding sets of the various national coins, weights and measures, and surrounded by a florally ornamented space from which sixteen avenues radiated to the outer space or circumference of the palace. In the sixteen sections thus formed the various nationalities had their products and groups arranged in a series, and all the series corresponding to one another from circumference to center. By passing around the galleries the spectator would come in succession upon similar groups of the different nationalities; while by passing along the avenues he would take successively the various groups of any and every nationality, each through its own entire series. Accordingly a tour of ten miles judiciously disposed, was enough to bring to an observer's attention the entire aggregate of groups within the building. By such means therefore, the best practicable facilities were supplied to each nationality to exhibit its own products to advantage, at once in union and in comparison with the like of other countries, while also the one 'special jury' and the ninety-four 'juries of classes,' for awarding testimonials and degrees of merit—the *prizes*, the *medals* and the *honorable mentions*—and, with them, the ten 'juries of groups,' for revising these awards under the final revision of a 'superior council,' all had the most ready and commanding observation of the objects composing the entire exhibit.

Were it a possibility to continue in permanence such an exhibit—a single area into which all the national arts were gathered and concentrated, like differently colored lights in the focus of an object-glass—there might thus be afforded to visitors an ever accessible telescopic vision, as it were, of the various civilizations of the earth, although ever so remote or scattered. But, even then, the visitors, however great their multitude, could never be expected to comprise more than a small fraction of the thinking and inquisitive classes of society. The best substitute therefore which the case admits of plainly seems to be of the sort adopted and carried out by the Federal Government for the use and satisfaction of these United States; that is to say, a well appointed and sufficiently numerous commission to witness, examine and report upon the Exposition and the groups and classes of objects therein represented; and the Reports to be printed by the Government for general distribution. Besides the primary 'General Survey of the Exposition,' from the pen of Charles B. Seymour, chairman of the Committee, instructed for that purpose by the Department of State, and its preface by N. M. Beckwith, U. S. Commissioner General, and President of the Commission, the Reports are before us, so far as their publication has been completed. By far the most voluminous, various and extended of the number is that of President Barnard, the title of which is employed above as an introductory heading to these remarks. It is an octavo of 650 pages, filled with descriptions, illustrations and theoretic determinations, illustrated with numerous clearly executed cuts on the pages, and concluded by eight elaborate and finely wrought engravings. The finished artistic execution of this and of all the volumes or reports is obviously due, in no small measure, to the taste, good judgment and accuracy of Prof. W. P. Blake, who superintended the publication, as its editor. It sets off to advantage the intrinsic value and eminent adornments of the report,—both the matter and the author's style of rendering it. Next to the privilege of one's own presence amid the immense and diversified assemblage of objects in the Exposition, is the experienced satisfaction and advantage of finding one's self in presence of a large collection of the most select and suggestive of the number, brought into one view through the medium of luminous, graphic and illustrated descriptions. The author not confining himself to mere delineation, as he passes from object to object, takes pains to instruct us in their subsisting mutual connections and dependencies, and to explain in each the distinctive uses of parts, the modes of general operation, and the rationale of effects. Often indeed, if we will stay to go deeper, he puts at our disposal his well understood powers of analysis, dissipates the fallacies which becloud the mechanician's conceptions, and reconciles those paradoxes which, to the popular mind, often carry the semblance of an inevitable discord between those two wedded and indissoluble partners, Theory and Practice. And we attend to these all the more earnestly that our author's opening chapter had impressed us, as at the vestibule and entrance of our survey, with the intimacy and imminence of 'The relation of invention to industrial progress.' That model chapter traces and exhibits with unwonted distinctness the dependence of art upon other art, and of art upon its own created auxiliaries: thus the steam engine first put within the workman's reach those operative and refined tools to which the steam engine itself owes its progressive improvement and existing completeness. In following out the like connections and dependencies we are also led to perceive, not indeed for the first time but with intensified vividness, how deeply art and invention project their influences into economic and social life, into trade and commerce, into civilizing effects abroad, into the habits of thinking and feeling at home, and even into politics and the nations's destiny. Thus, the cotton-gin expanded itself into a prime mover not only of all-pervading activities in the manufactory and on the ocean, but even of the vast combinations and issues themselves of war and peace. Here is no exaggeration; still we conceive, with our author, that not the individual inventor alone is to be recognized as the originating instrumentality of all this, except as one which the age itself had brought up into preparation for his invention, and in whom the invention sprang up because the age had created a demand for it.

The dependencies of industrial art may be spoken of in various senses,—*massively*, for instance, as resting upon force, its modifications and applications,—or *quantitatively*, as resting for the abundance and multiplication of its products, upon facile machinery, manipulation and skill,—or *inductively*, as resting upon knowledge and ingenuity for its origination and progress. A glance at the table of contents and headings of the chapters of the report, will suggest how considerably some such natural classification, whether or not so intended, has influenced our author in the selection of his subjects and in their arrangement. Of the eighteen chapters, five are occupied with the subject of *power* in its various mechanical relations; as, first, the prime movers, steam, air, water, electricity and their enginery; next, the transmission of power, then its accumulation, then its measurement and registration, and, lastly, its massive applications. The eight middle chapters are taken up mainly with the appliances, the methods and the instrumentalities of ingenuity, tact and sagacity, as used for the purpose of *production*, and acting through all the range and agencies of heat, cold, excitation, pressure and motion,—sometimes the production of improved material, and sometimes the production of improved effects, or of articles and implements for ornament and use, in their variety, their finish, and their aptitudes, as well as the rapidity and multitude of their manufacture. The concluding four chapters are occupied with the 'exact sciences' considered in their mechanical and practical relations. We read with wonder of the success with which measurements are carried to an exactness well nigh rivalling, to all intents, the mathematical itself,—of rods ascertained to a millionth of an inch in length, and of balances that perform to a twenty-millionth part of their burden. We are delighted to trace anew the progress by which the human eye has become enabled, through the perfection of object-glasses enormous in dimension, on the one hand, or of minute sizes on the other, to penetrate into the universe outwardly, and into the bosom of nature inwardly. We are let into the surprising secret by which mechanism is made to render numerical computations with greater exactitude and with immeasurably greater promptness than the mental faculties of the computer himself could realize. We are instructed how to make sound itself a thing of visible undulations, and how to apply a measuring scale to their continuance. Not much, it is true, of the Exposition, as the author himself is careful to say, was absolutely new, as respects *elementary* inventions; and, therefore, not much of that quality and essence could have place in any faithful account of it. The report is simply, and admirably, a representation by just and varied selections, of the stage of progress which industrial art and invention had reached in the year 1867. Although necessarily partial it still embraces a collection ample for its purpose; that is to say, for giving a near birdseye view of the Exposition, and, like the walks and avenues of the Exposition itself, diversified by occasional fragments of history and relics of legendary lore. Taken together it forms a resort where the engineer may obtain reassurance, the mechanic experience, the inventor impulse guidance and correction, and the man of intellect or of letters choice entertainment. The report is printed as a public document, and has not been ordinarily obtainable otherwise than by and through members of the United States Senate, each of whom, as we are informed, had the distribution of some fifteen entire series, each corresponding to the one of which this report is a constituent.

The United States was not largely represented, as respects numbers, in its own section of the Exposition. The country was too much occupied with new and extraordinary domestic questions. Industry was unsettled in many respects. The subject had not attracted the earliest attention; and the field was very distant. Yet our national exhibit, although not extended in scale, was excelled in quality only by France itself—and that in no very considerable degree—while the percentage of awards relative to the number of exhibitors was double the corresponding percentage for England and her colonies.

No extracts which our space would allow could do justice to the report, especially if not accompanied by the cuts or engravings; and if we were to instance and enlarge upon passages and descriptions that appear specially important, it would convey no conceptions to the reader comparable with what he will obtain by a reference to the work itself. We only add, in justice to the distinguished author, that, while he is thoroughly American in a due anxiety to set forward the claims of his countrymen, it is with an obvious impartiality toward all the competitors, and with a diligence whose regulating principle is truth and an endeavor for the benefit of mankind in general.

ART. XXII.—*On Norite or Labradorite Rock;* by T. STERRY HUNT, LL.D., F.R.S.

[Read before the American Association for the Advancement of Science, at Salem, August, 1869.]

THE various rocks composed essentially of a triclinic or anorthic feldspar, with an admixture of hornblende, pyroxene, hypersthene or diallage, have by lithologists been designated by the names of diorite, dolerite, diabase, hypersthenite and gabbro, among others. The latter name has by many been regarded as synonymous with euphotide. I however pointed out many years since that the true euphotide is not a feldspathic rock, but consists of a mixture of diallage with saussurite, a white heavy silicate apparently identical with zoisite. By an admixture of labradorite or an allied feldspar, however, euphotide passes into the so-called gabbro, which I have defined as a diallagic diabase (this Journal, II, xxvii, 336), and which is closely related to norite. The name of hypersthene rock or hypersthenite (sometimes contracted into hyperite), was given by MacCulloch* to a rock consisting of labradorite, or a related feldspar, and hypersthene, found by him in the Western Islands of Scotland, and subsequently recognized by Emmons in the Adirondack Mountains of northern New York. By both of these observers it was regarded as an erupted rock. In 1851 I detected it among the Laurentide hills of Canada, where, as in New York, it extends over considerable areas. Farther examinations of this rock in place showed that though hypersthene, generally in very small proportion, is a frequent element, it is often

* MacCulloch, Geology of the Western Islands, i, 385–390.

replaced by a green granular pyroxene, and still more often both of these are wanting, so that we have a rock composed almost entirely of a triclinic feldspar, whose composition is generally near that of labradorite, but varies in different examples from that of andesine to near that of anorthite. To these rocks I provisionally applied the name of anorthosites, the pure feldspathic type being regarded as normal anorthosite, associated with which, however, were to be found hypersthenic and pyroxenic varieties. Red garnet, epidote, a black mica, and more rarely dichroite and quartz, are all occasionally found sparingly disseminated in these anorthosites of New York and Canada, which cannot be distinguished from those first observed by MacCulloch in the Isle of Skye, as I have convinced myself by an examination of the specimens there collected by him, and now preserved in the collections of the Geological Society of London. Titaniferous iron ore (menaccanite) also frequently occurs in grains and masses in these rocks, both in Skye, and in North America, where it sometimes forms beds or masses of considerable size. Details as to the chemical and mineralogical characters of these rocks will be found in the L. E. & D. Philos. Magazine for May, 1855, and also in the Geology of Canada, 1863, pages 588–590.

The subsequent investigations of Sir William Logan have shown that these anorthosites in Canada belong to a great series of stratified crystalline rocks which by the geological survey of Canada have been designated the Labrador or Upper Laurentian series, and which repose unconformably upon the older or true Laurentian gneiss and limestones. The area of the Labrador formation most examined lies in the counties of Argenteuil and Terrebonne, to the north and northwest of Montreal, and has a breadth of more than forty miles. It is however met with on the northeast shore of Lake Huron, according to Dr. Bigsby,* and at several points below Quebec, notably in the parish of Château-Richer, at Bay St. Paul, and around Lake St. John on the Saguenay, where it occupies a large area. Proceeding north-eastward along the left bank of the St. Lawrence, Mr. Richardson has lately observed it at the mouth of Pentecost river, about 160 miles below the entrance to the Saguenay, and I have found it forming the shore of the Bay of Seven Islands forty miles farther down. This area is probably connected with the wide extent of this rock observed by Prof. Hind on the river Moisie. In all of these regions it appears to be surrounded and limited by the ordinary Laurentian gneiss. Bayfield, moreover, describes a rock with a base of labradorite as forming the coast for several miles near Mingan. Finally, it is widely spread on the coast of Labrador, where its characteristic mineral was first found, and from whence it takes its name.

* Geology of Canada, 1863, page 480.

Prof. A. S. Packard, Jr., has given us valuable information with regard to the occurrence of labradorite rocks at some points on the Labrador coast.* One of its localities is at Square Island, just north of Cape St. Michel, where the rock consists chiefly of crystalline labradorite smoky gray in color, translucent, and opalescent with greenish reflections. This feldspar often shows cleavage planes two inches broad, and is associated with a little vitreous quartz and with coarsely crystalline hypersthene, which appears in relief on the weathered surfaces. This labradorite rock, according to Prof. Packard, is surrounded by and probably rests upon Laurentian gneiss. At Domino Harbor he found domes or bosses of a similar labradorite resting upon strata which consist in great part of a slightly schistose quartzite, having for its base a granular vitreous quartz, and enclosing grains of black hornblende, more rarely hypersthene, black mica, and red garnet. Feldspar is generally wanting, but in some parts these quartzites become gneissic, and they were nowhere seen in uncomformable contact with the Laurentian gneiss of the vicinity. These quartzose strata Prof. Packard refers, with some doubt, to the Huronian system. The minerals which they contain are not however met with, so far as known, in the Huronian quartzites, and on the contrary, are very characteristic of the quartzites of the Laurentian system, which attain a great thickness in many parts of its distribution. The overlying domes of labradorite rock, which Prof. Packard was inclined to regard, in this case, as erupted through Huronian quartzites, are probably nothing more than outlying portions of the newer Labrador formation resting upon the Laurentian strata, as already observed by him at Square Island. Along the western coast of the island of Newfoundland Mr. Jukes observed at Indian Head and at York Harbor dark colored rocks composed of labradorite and hypersthene, and others of albite (?) and hypersthene, which may probably be found to belong to the Labrador series.

Rocks composed chiefly of labradorite or a related feldspar greatly predominate in the Labrador series, but these, at least in the area near Montreal, which is the one best known, are interstratified with beds of a kind of diabase in which dark green pyroxene prevails, with crystalline limestone similar in mineralogical characters to that of the Laurentian system, and more rarely with quartzites and thin beds of orthoclase gneiss. I have more than once insisted upon the rarity of free quartz and the general basic character of the rocks in this series, an observation with which I am credited in Dana's Manual of Geol-

* On the Glacial phenomena of Labrador and Maine. Mem. Bost. Acad. Nat. Hist., vol. I, part ii, pp. 214–217.

ogy (p. 139), where it seems to be applied to the whole of the rocks there classed as Azoic, including the Laurentian, Labradorian and Huronian systems. It is, in fact, remarkable that the silicated rocks of the latter two consist chiefly of labradorites, diorites and diabases; gneissic and granitic rocks being exceedingly rare among them, though quartzites abound in the Huronian. In the Laurentian system, on the contrary, though basic silicated rocks are not wanting, orthoclase gneisses, often granitoid in structure, and abounding in quartz, predominate.

The anorthosite rocks of the Labrador series present great variations in texture, being sometimes coarsely granitoid, and at other times finely granular. They not unfrequently assume the banded structure of gneiss, lines of pyroxene, hypersthene, garnet, titanic iron ore or mica marking the planes of stratification. Probably three-fourths of the anorthosites of this series in Canada, whether examined in place or in the boulders which abound in the St. Lawrence valley, consist of pure or nearly pure feldspar rocks, in which the proportion of foreign minerals will not exceed five hundredths. Hence we have come to designate them by the name of labradorite rock. The colors of this rock are very generally some shade of blue, from bluish-black or violet to bluish-gray, smoky gray or lavender, more rarely purplish passing into flesh red, greenish-blue, and occasionally greenish or bluish-white. The weathered surfaces of these labradorite rocks are opaque white. The anorthosites which occupy a considerable area in the Adirondack region, as described by Emmons in his report on the Geology of the Northern district of New York, and as seen by me in hand specimens, closely resemble the rocks of the Labrador series in Canada.

In all of these localities the coarse or granitoid varieties often hold large crystalline cleavable masses, generally polysynthetic macles, and frequently exhibiting the peculiar opalescence which belongs to labradorite. Although rocks composed of labradorite or similar feldspars, with hornblende or pyroxene, occur in various other geological formations, both as indigenous greenstones and as erupted masses, they never, so far as my observation in North America goes, exhibit the peculiar character just described; namely, that of a granular or granitoid rock composed of nearly pure labradorite or some closely related feldspar, frequently opalescent, and generally of a bluish color, often violet, smoky blue or lavender blue. This type of rock seems in North America to characterize the Labrador series.

It may here be remarked as an interesting fact bearing on the distribution of the Labrador series, that two large boulders of labradorite rock, one of the beautiful dark blue variety, are found on Marblehead Neck on the coast of Massachusetts. It does not seem probable that these masses could have been derived from any of the far off localities already mentioned. and the fact that the gneiss of eastern Massachusetts is, as I have recently found, in part of Laurentian age, suggests that an outcrop of the Labrador series may exist in some locality not far removed. In this connection it may be added that I have lately found characteristic labradorite and hyperite rocks in southern New Brunswick, a few miles east of St. John, occupying a position between the Laurentian and the Huronian or Cambrian rocks, which there make their appearance, accompanied by Lower Silurian strata, to the south of the great Carboniferous basin of the region. This interesting locality was recently pointed out to me by Mr. G. F. Matthew of St. John, to whom we are indebted for a great part of our knowledge of the geology of southern New Brunswick. Chester and Bucks counties in Pennsylvania, and the Wichita Mountains in Arkansas, are cited in Dana's Mineralogy as localities of labradorite, but as I have never examined specimens from these places, I am unable to say whether they resemble the characteristic anorthosites of the Labrador series already described.

The name of norite, in allusion to Norway, was given by Esmark to a rock composed chiefly of labradorite, which is found in several localities in that country.* I had already noticed the close resemblance between two specimens of norite obtained from Krantz of Berlin, and the labradorite rocks of North America just noticed, when in 1867 I had the opportunity of examining at the Universal Exhibition at Paris, a collection of Norwegian rocks selected for ornamental purposes, exhibited by the Royal University of Christiania. Prominent among these was a series of the norites, which could not be distinguished from the labradorite rocks of the Upper Laurentian or Labrador series of this continent. In a printed note accompanying this collection from the University it is said that the numerous varieties of rocks consisting of labradorite with hypersthene, diallage and bronzite, have, in the geological map of Southern Norway, published at Christiania in 1866, been designated by the common name of gabbro. This note at the same time suggests that "the name of norite should be preserved for certain varieties of gabbro rich in labradorite, which varieties may in great part with justice be called labradorite rock, since labrador feldspar is their predominent element." With this excellent suggestion I heartily concur, remarking, however that the name of gabbro, as an ill-defined synonym for certain anorthosite rocks, including in part diorite, diabase, hyperite, and even confounded with the non-feldspathic rock euphotide, may very well be dispensed with in lithology.

* See farther Zirkel. Petrographie, II, 131.

By referring to the geological map just mentioned, it will be seen that these so-called gabbros occupy considerable areas in the Laurentian gneiss region of Norway. By the authors of the maps, Messrs. Kjerulf and Dahl, these gabbros are regarded as eruptive, though they are described at the same time as often assuming the character of stratified rocks. It should however be noticed that these geologists go so far as to regard the whole of the granitic gneiss of the region as unstratified and of plutonic origin.

The specimens of these norites exhibited in Paris were in blocks polished on one side, and as was observed in the note accompanying them, presented a curious resemblance to certain varieties of marble. It is worthy of remark that Emmons in his report on the Geology of the Northern District of New York, suggested the application of the labradorite rocks of Essex county as a substitute for marble (pages 29, 418). An ornamental vase of the same rock turned in a lathe with the aid of a black diamond, has been in the Museum of the Geological Survey of Canada since 1856.

Of the collection of norites from Norway the specimens from Sogndal and Egersund presented fine varieties of grayish or brownish violet tints, while a dark violet norite came from Krageroë and also from the islands of Langoë and Gomoë, and a white granular variety from the gulf of Laerdal in the diocese of Bergen.

It is only in rare cases that the cleavable feldspar of these norites exhibits the peculiar opalescence which distinguishes the finer labradorite found in some parts of the coast of Labrador. Opalescent varieties of this feldspar are however occasionally met with in the area near to Montreal, and in northern New York. In the Paris Exhibition of 1867 there were exhibited from Russia, large polished tables of a beautiful violet colored granitoid norite, portions of which exhibited a fine opalescence. This rock, I was informed, comes from a mountain mass in the Government of Kiew, but of its geognostical relations I am ignorant.

These peculiar labradorite rocks, presenting a great similarity in mineralogical and lithological character, have now been observed in Essex county, New York, and through Canada at intervals from the shore of Lake Huron to the coast of Labrador. They are again met with in southern New Brunswick, in the Isle of Skye, in Norway, and in southwestern Russia, and in nearly all of these localities are known to occur in contact with and apparently reposing like a newer formation upon the ancient Laurentian gneiss. Giekie in his memoir on the geology of a part of Skye,* appears to include the norites or

* Quar. Jour. Geol. Soc., xiv., p. 1.

hypersthenites of that island with certain syenites and greenstones, which he describes as not intrusive, though eruptive after the manner of granites (loc. cit., p. 11–14). The hypersthenites are represented in his map as occurring to the west of Loch Slapin. Specimens in my possession from Loch Scavig, a little further west, and others in MacCulloch's collection from that vicinity, are however identical with the North American norites, whose stratified character is undoubted. I called attention to these resemblances in the Dublin Quarterly Journal for July, 1863,* and Haughton, who in 1864 visited Loch Scavig, has since described and analyzed the rock of that locality, which consists of labradorite, often coarse grained, with pyroxene and menaccanite, and is evidently, according to him, a bedded metamorphic rock (Dublin Quar. Jour., 1865, p. 94). He, it may be remarked, designates it as a syenite, a term which most lithologists apply to rocks whose feldspar is orthoclase.

I desire to call the attention of both American and European lithologists to this remarkable class of rocks, of which the norites may be regarded as the normal and typical form, in the hope that they may be induced to examine still farther into the question of the age and geognostical relations of these rocks in various regions, and to determine whether the mineralogical and lithological character which I have pointed out are geological constants.

ART. XXIII.—*On the cause of the color of the Water of Lake Leman, Geneva;* by AUG. A. HAYES, M.D., Assayer to State of Massachusetts.

THE traveler, who enters Switzerland at Geneva, always has his attention arrested by the beautiful azure color which the water of Lake Leman presents, especially when, as one looks into its depths, the color is in contrast with the white reflection of clothing below the surface, at points where the laundresses pursue their avocations.

* I, at the same time, called attention to the Laurentian aspect of the crystalline limestones of Iona, which I found in MacCulloch's collection. Limestones not unlike these occur in Skye, intermixed with serpentine, and are, according to Mr. Giekie, associated with the protruded syenites of that region. With all deference to the authority of that eminent geologist, I cannot help suggesting that a re-examination of the district would show that the highly-inclined metamorphic crystalline limestones, holding serpentine, and associated with syenitic rocks, belong to an older system (probably Laurentian), and are thus distinct from the nearly horizontal fossiliferous liassic limestones near by, which are only locally altered by intrusive rocks. American geologists will at once recall the mis-conception which led most of our best observers during many years to look upon the old Laurentian limestones of New York and New Jersey as altered portions of the overlying paleozoic strata.

Many will remember the expression of Sir H. Davy, that "this color is doubtless due to some compound of iodine," and not only chemists, but geologists have speculated on the cause of this coloration, quite frequently with opposite opinions.

Both in composition and general characters, this water belongs to a class I have been accustomed to describe as "White waters," or colorless waters, which, chemically considered, always hold a salt called crenate of lime in solution, and mark in their color the existence of lime salts, in their course as rivers, or in contact with them, as reposing in true lakes. At many points in Switzerland these white waters are found, and indicate clearly the occurrence of calcareous matter, more extensively diffused than surface observations of the rocks would allow in some districts.

Among the Tyrolese Alps, too, lakes and streams present the same cerulean hue, which gives character and beauty to the water of Lake Leman, and I have seen even small collections of water there apparently as highly colored as the more noted lakes. "White waters," when clear, always present this hue, and when turbid, a green hue, due to reflection from particles of solid matter. In the summer of 1858, I commenced a careful analysis of the water of Lake Leman at Geneva, and had found a general accordance with the published statements of composition; but the special search for coloring matter, was prevented by the inopportune recurrence of rain, and subsequent disappointment at a point on the Rhone above the lake.

Since that time this water has been analyzed by distinguished chemists, such as Will, Dafour, and Blanche, whose results only show the presence of more salts in number in the solid matter, and the slight variations in proportions which we should expect would occur, under variations of volume and temperature, in the water at different seasons.

These analyses, I learned, were made in the usual way of evaporating the water for the solid products, and driving off and collecting the gases, a method which enables us to answer many questions, but does not permit the nicer determinations of organic bodies, if present, in a natural or an altered state. Analysis so conducted would not allow us to answer the question in relation to the cause of color, unless it could be traced to some known or unknown fixed compound. Nor would such an analysis determine the weight accurately of the whole amount of matter, naturally dissolved in the water, as it is easy to prove that a loss of matter takes place during the evaporation, even if conducted at a moderate temperature—the great point of state of hydration of the organic salts, and to some extent that of the saline matter, is ignored entirely when we proceed in this way to determine the quantity and kind of constituents.

Nearly all waters contain living organisms, and their germs, these matters, in a decomposing state, organic acids, either with or without bases, in the form of salts, most easily changed by heat or even by concentration. These substances are very important constituents, in connection with the uses of the water, and I could offer many illustrations of damage in manufacturing and unfitness for consumption, traceable directly to the presence of such bodies in waters otherwise desirable, and proper for extended consumption.

The mode adopted in my examination of the water of Lake Leman is that which I have usefully applied in a large number of cases, and with modifications, it is applicable to all waters, in connection with other well known steps of analysis.

A large volume of the water of Lake Leman was mixed with a small portion of a diluted solution of sub-acetate of lead quickly and uniformly diffused. Another portion was treated in the same way, with a water solution of pure soap—both precipitates slowly formed, were collected in a moist state, subsequently examined by the microscope, and were found to contain only the ordinary constituents of white waters, when so treated.

The negative results of these trials in this connection, were sufficient to prove the absence of all coloring or colored bodies in this water—the strong attraction of the basic salt of lead for all coloring matter is well known—its power of removing colored infusoria is equally great. The calcareous soap product formed from the test removes all suspended matter, and permits us to detect organic forms with ease and certainty, after the fatty matters are dissolved on a glass slide.

It is obvious that in cases of complete analysis of waters, these precipitates should be subsequently chemically treated, and their state of hydration found, and engaged compounds separated and weighed.

Chemical analysis, thus conducted, having thrown no light on the cause of color in this water, has proved the absence of coloring substances, and placed it in the list of those waters, which do not exhibit the color seen in this lake; we are, therefore, led to ascribe the origin of its peculiar tint to natural influences, namely, the reflection and refraction of an azure sky in a colorless water.

The sky coloration of this part of Switzerland early engaged the observation of Saussure, who even experimented on its depth of color, while retaining its blue tint. All the conditions favoring almost constant blueness of sky, are present in this, and other parts of Switzerland in a marked degree, and I believe that extended observation will always connect the blue tint of white water with the deep azure hue of the clear sky above it.

By carefully watching the influence of the light from the sky on the water of this lake, I observed here as elsewhere that depth of color and tint in the water were modified greatly, or even lost under varied light from the sky. As the sun declined the azure tint was replaced by a grayish hue, or a light gray color was the closing hue of a series of shades of color. If the clear sky became flecked with small cloud surfaces, the water responded in unequal coloration, as if the water mirrored the sky, under this condition of beauty.

In other countries, there are bodies of colorless water which do not exhibit the coloration, commonly seen in Lake Leman water. Such lŏcalities are not favored with clear blue skies through atmospheric constitution, and bluish greenness of tint is the nearest approach to azure hue, which the sky permits, excepting perhaps at rare moments.

The negative results of chemical analysis, and the sufficiency of the effect of reflected and refracted light of the sky, which is over the water of Lake Leman, led me to the conclusion that the cause of color is found in the peculiar hue of the sky, so transmitted to the eye by a colorless water.

Boston, Mass., December 10th, 1869.

ART. XXIV.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School. No. IX.—On the Potassio-Cobaltic Nitrite known as Fischer's Salt, and some analogous and related compounds;* by SAMUEL P. SADTLER.

THE composition of the double nitrite of cobalt and potash, known by the different names of "Fischer's Salt" and "Cobalt-yellow," has long been an open question. The following is a brief statement of the views advanced on the subject. Fischer* the discoverer of the salt made no analyses of it. St. Evre† who rediscovered it gave as a formula for it $K_2ΘN_2Θ_4+ЄoΘN_2Θ_4$, but does not give the analytical data. Stromeyer‡ subsequently showed the incorrectness of this view and wrote the formula $Єo_2Θ_3, 2N_2Θ_3+3(K_2ΘN_2Θ_3)+2H_2Θ$. This formula is peculiar in making the atom $Єo_2Θ_3$ combine with 2 atoms of $N_2Θ_3$. We shall discuss the formula and results farther on. Erdmann§ first pointed out a distinction between the salt formed in neutral solutions and the salt formed in acid solutions, which latter he considers as a normal salt. He gives both

$$2ЄoΘ, 3N_2Θ_3+3(K_2ΘN_2Θ_3)+3N_2Θ, \text{ and } Єo_2Θ_3 3N_2Θ_3+3(K_2ΘN_2Θ_3)+3H_2Θ$$

* Pogg. Ann., lxxii, 477 and lxxiv, 124.
† Jr. pr. Ch., 54, 84 and 58, 185.
‡ Ann. Ch. u. Ph., xcvi, 218.
§ Jr. pr. Ch., lxxiii, 598.

or as we shall write it $Co_26N\Theta_2+6(KN\Theta_2)+3H_2\Theta$. Braun* the last writer on the subject, passes most of the preceding work in review. He takes up Stromeyer's results, and rejecting his views as to the composition of the salt analysed by him, figures for it a number of ingenious but somewhat complicated formulas. He considers that neither the "neutral salt" nor the "acid salt" of Erdmann can be regarded as anything but mixtures or "poly combinations," and for the first of them considered as such he gives a still more ingenious and complicated formula. We quote it as reduced to its empirical form by Blomstrand:† $Co_{62}K_{59}N_{112}H_{20}O_{454}$.‡ Braun's own results are expressed first by a formula containing both $Co_2\Theta_3$ and $Co\Theta$, then by one containing $Co_2\Theta_3$, $Co\Theta$, $N_2\Theta_3$ and $N_2\Theta_5$ and finally by the following:

$$3(Co_2\Theta_3,\ 3N_2\Theta_3+4K_2\Theta,\ 4N_2\Theta_3+2H_2\Theta)+2(Co_2\Theta_3,\ H_2\Theta,\ 2N_2\Theta_3+K_2\Theta,\ N_2\Theta_3+3H_2\Theta).$$

The experiments made to settle its composition and the results obtained are as follows: St. Evre ignited the salt in a stream of nitrogen. Nitric oxyd was given off and the residue was a black oxyd, which on contact with HCl gave Cl and with $C_2H_2\Theta_4$ gave $C\Theta_2$. This I cannot regard as conclusive, as mere ignition per se will not break up the $KN\Theta_2$, so that the residue was not pure $Co_2\Theta_3$; moreover the $N_2\Theta_3$ in breaking up may have given an atom of Θ to form the $Co_2\Theta_3$. Stromeyer found that $NaH\Theta$ and $BaH_2\Theta_2$ decompose it on gentle warming, even with exclusion of air, separating the brown hydrated $Co_2\Theta_3$ which dissolves in $C_2H_4\Theta_2$ with a brown, and in $C_2H_2\Theta_4$ with a green color. This observation is of undoubted value. He says also that on mixing the neutral solutions, the precipitate is slow in forming, and forms by an absorption of Θ, as is shown by dipping the connecting tube under a cylinder of air or oxygen. Erdmann confines himself to an examination of this last observation of Stromeyer's and finds that the "neutral salt" can be formed in an atmosphere of pure $C\Theta_2$, and that therefore there can be no absorption of Θ in the case. Braun finds that $KH\Theta$ acts very little upon the salt, merely changing its color from yellow to a dirty yellowish-green. $NaH\Theta$, $BaH_2\Theta_2$, $CaH_2\Theta_2$ separate at a boiling heat the brownish-black hydrated $Co_2\Theta_3$. This is confirmatory of Stromeyer's observation. Carbonate of silver heated with water and Fischer's salt gave with separation of the hydrated $Co_2\Theta_3$, crystals of what from Braun's description were probably $AgN\Theta_2$. KCy did not decompose it.

* Zeitsch. Anal. Ch., vii, 313. † Chemie der Jetztzeit, p. 414.
‡ Should be O 508.

My own experiments directed toward the solution of the question of $\text{Ꞓ}o\Theta$ or $\text{Ꞓ}o_2\Theta_3$ were as follows: I found Erdmann's observations as to the formation of the "neutral salt" in an atmosphere of $\text{Ꞓ}\Theta_2$ correct. I added by means of a funnel tube a solution of $KN\Theta_2$ boiled to expel the air, to a boiled solution of $\text{Ꞓ}o\,Cl_2$, placed at the bottom of a partially closed vessel, into which a strong stream of $\text{Ꞓ}\Theta_2$ had been passing for some time. The salt began nevertheless to form slowly. Wishing to sift the matter more thoroughly, I made a series of experiments in eudiometer tubes over mercury. Into a eudiometer tube filled with mercury and perfectly free from air, I threw up a boiled solution of $\text{Ꞓ}oCl_2$ and then one of $KN\Theta_2$. The salt began to form soon at the juncture of the two liquids and then deposited steadily though slowly. After a number of hours not the slightest bubble of air was to be seen. The absence of all chance of oxydation here, either from air or excess of nitrous acid, shows conclusively the protoxyd nature of this "neutral salt." The "acid salt" was formed in the same manner—first a boiled solution of $\text{Ꞓ}oCl_2$, then acetic acid, and then a boiled $KN\Theta_2$ solution. A rapid evolution of gas ensues and the salt forms and falls in a layer on the top of the mercurial column. In another instance a small crystal of $\text{Ꞓ}oCl_2$ was sent up and then acetic acid and then $KN\Theta_2$. The formation of the salt was almost instantaneous and the evolution of gas exceedingly rapid. Before drawing any conclusions from this, however, the action of acetic acid on $KN\Theta_2$, out of access of air, was to be studied. Gmelin* states that, when treated with acid out of access of air, nitric oxyd is evolved while the liquid takes up $N\Theta_2$ and $N_2\Theta_5$. This evolution was found to take place readily over the mercury and the gas answered to the test of ferrous sulphate and was colored red on admission of air, like the gas evolved in the formation of the salt. The question now is whether the liberated Θ is taken up in the formation of the salt to oxydize the $\text{Ꞓ}o\Theta$, to convert the excess of nitrite into nitrate. The question cannot be definitely settled, until we have some delicate test for a small quantity of nitrate in the presence of a large quantity of nitrite. But there is one thing which I regard as significant. Erdmann made one of his preparations of the "acid salt," by filtering the mixture of neutral solutions into pure acetic acid. Now the greater the excess of acid, the quicker would be the conversion of nitrite into nitrate, and we should look for a very small amount of the double nitrite salt. Yet it formed as readily, and analysis proved it to possess the same constitution as the other preparations. The inference from this is, that the

* Cav. Soc. ed. vol. ii, p. 382.

sesquioxyd-forming power of the Ꞓo is sufficient to enable it to take liberated oxygen.

Recourse was now had to analysis as a means of determining the question. Six distinct preparations of the salt in all were made and analyzed. In preparing the salt, the distinction made by Erdmann in regard to the formation of different compounds in neutral and acid solutions, was recognized and the salt was invariably formed in a solution, strongly acidified by acetic acid in the beginning, and kept so until the end by the addition of acid, if necessary. The salt of cobalt used was the chlorid, and, in all but the first two preparations, the solution was boiled to expel air and made acid. A strong solution of $KN\Theta_2$ was then added and the mixture was left to stand: 6 to 12 hours generally proved sufficient, and it was then filtered and washed, according to Erdmann's direction, with a solution of potassic acetate of about 10 per cent which was displaced by 80 per cent alcohol. The salt was then dried, first over the water-bath and then in a water-oven exactly at 100°. I saw no evidence of a decomposition at this temperature alluded to by Erdmann.

The results of full analyses of these six preparations warrant me I think in presenting the following conclusions:—

1st. That Fischer's salt is a *Tri-potassic-Cobaltic-Nitrite*, its essential formula being $\text{Ꞓo}_2\Theta_3, 3N_2\Theta_3+3(K_2\Theta, N_2\Theta_3)+Aq$, or $\text{Ꞓo}_2 6N\Theta_2+6(KN\Theta_2)+Aq$.

2nd. That it can be formed with $4H_2\Theta, 3H_2\Theta, 2H_2\Theta, H_2\Theta$, or anhydrous, according to the degree of concentration of the solutions used, passing in color from a light yellow to a dark greenish-yellow.

3rd. That in consequence of such dependence, we can, in in most preparations, fix no absolute point, but are liable to have a mixture of salts of different degrees of hydration.

The analytical methods used in the analyses of the salt were the following:—

The Ꞓo was determined first together with the K, as a double sulphate having the invariable constitution $\text{Ꞓo}_2K_6 5\text{Ꞩ}\Theta_4$. This sulphate has a distinct fusing-point, and affords an accurate means of determination. It will be discussed farther on. This is then dissolved, the solution made ammoniacal and brought to boiling, when the Ꞓo is thrown down as ꞒoꞨ. This is roasted and, after treatment with aqua regia and sulphuric acid, is weighed as neutral $\text{ꞒoꞨ}\Theta_4$. Or the Ꞓo was thrown down from the solution of the double sulphates as peroxyd by acetate of soda and chlorine, and then reduced by hydrogen to the metallic state.

The potash is then determined by difference.

The nitrogen was determined, either together with the $H_2\Theta$ by Gibbs's modification of Bunsen's method, which will be again alluded to, or directly by volume with the Sprengel-pump.

The $H_2\Theta$ either as above, or by combustion with Cu in a stream of $C\Theta_2$.

The analytical data and results are appended.

Preparation No. 1.

·2011 gr. salt gave ·1732 gr. $Co_2K_65S\Theta_4=44{\cdot}75$ p. c. $Co\Theta+K_2\Theta$ gave also ·0656 gr. $CoS\Theta_4=15{\cdot}78$ p. c. $Co\Theta=17{\cdot}47$ p. c. $Co_2\Theta_3$.

·1626 gr. salt gave ·1403 gr. $Co_2K_65S\Theta_4=44{\cdot}83$ p. c. $Co\Theta+K_2\Theta$ gave also ·0529 gr. $CoS\Theta_4=15{\cdot}74$ p. c. $Co\Theta=17{\cdot}42$ p. c. $Co_2\Theta_3$.

·5147 gr. salt gave 112·7 cc. nitrogen at 15·25° and 483·2 mm. pres. $=16{\cdot}56$ p. c. $N=44{\cdot}95$ p. c. $N_2\Theta_3$.

·9410 gr. salt gave 167·6 cc. nitrogen at 15·25 and 601·6 mm. pres. $=16{\cdot}76$ p. c. $N=45{\cdot}48$ p. c. $N_2\Theta_3$.

1·1131 gr. salt gave ·0793 gr. $H_2\Theta=7{\cdot}00$ p. c. $H_2\Theta$.

1·3418 " " ·0937 " " 6·98 " "

Preparation No. 2.

·1082 gr. salt gave ·0955 gr. $Co_2K_65S\Theta_4=45{\cdot}86$ p. c. $Co\Theta+K_2\Theta$ gave also ·0408 gr. $CoS\Theta_4=16{\cdot}16$ p. c. $Co\Theta=17{\cdot}88$ p. c. $Co_2\Theta_3$.

·1222 gr. salt gave ·1074 gr. $Co_2K_65S\Theta_4=45{\cdot}66$ p. c. $Co\Theta+K_2\Theta$ gave also ·0455 gr. $CoS\Theta_4=15{\cdot}96$ p. c. $Co\Theta=17{\cdot}66$ p. c. $Co_2\Theta_3$.

·4192 gr. salt gave 102·83 cc. nitrogen at 18·25° and 462·6 mm. pres.$=17{\cdot}57$ p. c. $N.=47{\cdot}70$ p. c. $N_2\Theta_3$.

·4376 gr. salt gave

·6328 " " ·0346 gr. $H_2\Theta=5{\cdot}46$ p. c. $H_2\Theta$.

·5494 " " ·0296 gr. $H_2\Theta=5{\cdot}39$ p. c. $H_2\Theta$.

Preparation No. 3.

·6215 gr. salt gave ·5682 gr. $Co_2K_65S\Theta_4=47{\cdot}50$ p. c. $Co\Theta+K_2\Theta$ gave also ·0797 gr. $Co=12{\cdot}82$ p. c. $Co=18{\cdot}04$ p. c. $Co_2\Theta_3$.

·5838 gr. salt gave ·5349 gr. $Co_2K_65S\Theta_4=47{\cdot}60$ p. c. $Co\Theta+K_2\Theta$ gave also ·0740 gr. $Co=12{\cdot}68$ p. c. $Co=17{\cdot}83$ p. c. $Co_2\Theta_3$.

·4451 gr. salt gave ·4088 gr. $Co_2K_65S\Theta_4=47{\cdot}71$ p. c. $Co\Theta+K_2\Theta$ gave also ·0574 gr. $Co=12{\cdot}39$ p. c. $Co=18{\cdot}14$ p. c. $Co_2\Theta_3$.

·5796 gr. salt gave ·5329 gr. $Co_2K_65S\Theta_4=47{\cdot}77$ p. c. $Co\Theta+K_2\Theta$ gave also ·0735 gr. $Co=12{\cdot}68$ p. c. $Co=17{\cdot}83$ p. c. $Co_2\Theta_3$.

With 1·6634 gr. salt, combustion-tube lost ·3616 gr., of which $CaCl_2$ tube took up ·0710 gr.$=4{\cdot}27$ p. c. $H_2\Theta$ leaving ·2906 gr.$=17{\cdot}47$ p. c. $N.=47{\cdot}42$ p. c. $N_2\Theta_3$.

With 1·5123 gr. salt, combustion-tube lost ·3302 gr., of which $CaCl_2$ tube took up ·0610 gr.$=4{\cdot}03$ p. c. $H_2\Theta$ leaving ·2692 gr.$=17{\cdot}80$ p. c. $N.=48{\cdot}32$ p. c. $N_2\Theta_3$.

Preparation No. 4.

·6677 gr. salt gave ·6073 gr. $Co_2K_65S\Theta_4$=47·26 p. c. $Co\Theta+K_2\Theta$ gave also ·2258 gr. $CoS\Theta_4$=16·36 p. c. $Co\Theta$=18·11 p. c. $Co_2\Theta_3$.

·3590 gr. salt gave ·3264 gr. $Co_2K_65S\Theta_4$=47·24 p. c. $Co\Theta+K_2\Theta$ gave also ·1226 gr. $CoS\Theta_4$=16·52 p. c. $Co\Theta$=18·29 p. c. $Co_2\Theta_3$.

With 1·1138 gr. salt, combustion-tube lost ·2461 gr., of which $CaCl_2$ tube took up ·0439=3·94 p. c. $H_2\Theta$ leaving ·2022 gr. =18·15 p. c. N.=49·27 p. c. $N_2\Theta_3$.

With 1·2494 gr. salt, combustion-tube lost ·2674 gr., of which $CaCl_2$ tube took up ·0407=3·26 p. c. $H_2\Theta$, leaving ·2267 gr. =18·14 p. c. N.=49·25 p. c. $N_2\Theta_3$.

With 1·1587 gr. salt, combustion-tube lost ·2533 gr., of which $CaCl_2$ tube took up ·0432=3·73 p. c. $H_2\Theta$ leaving ·2101 gr. =18·13 p. c. N.=49·20 p. c. $N_2\Theta_3$.

Preparation No. 5.

·2895 gr. salt gave ·2633 gr. $Co_2K_65S\Theta_4$=47·26 p. c. $Co\Theta+K_2\Theta$ gave also ·0382 Co=13·20 p. c. Co=18·56 p. c. $Co_2\Theta_3$.

·3993 gr. salt gave ·3644 gr. $Co_2K_65SO_4$=47·42 p. c. $Co\Theta+K_2\Theta$ gave also ·0531 Co=13·30 p. c. Co=18·70 p. c. $Co_2\Theta_3$.

·5747 gr. salt gave ·5243 gr. $Co_2K_65S\Theta_4$=47·40 p. c. $Co\Theta+K_2\Theta$ gave also ·0769 gr. Co=13·38 p. c. Co=18·82 p. c. $Co_2\Theta_3$.

·5959 gr. salt gave ·5443 gr. $Co_2K_65SO_4$=47·46 p. c. $Co\Theta+K_2\Theta$ gave also ·0768 gr. Co=12·89 p. c. Co=18·14 p. c. $Co_2\Theta_3$.

With 1·2557 gr. salt, combustion-tube lost ·2758 gr., of which $CaCl_2$ tube took up ·0459=3·66 p. c. $H_2\Theta$ leaving ·2299 gr. =18·31 p. c. N.=49·69 p. c. $N_2\Theta_3$.

With 1·1464 gr. salt, combustion-tube lost ·2556 gr., of which $CaCl_2$ tube took up ·0479=4·18 p. c. $H_2\Theta$ leaving ·2077 gr. =18·12 p. c. N.=49·18 p. c. $N_2\Theta_3$.

Preparation No. 6.

·8154 gr. salt gave ·7644 gr. $Co_2K_65S\Theta_4$=48·71 p. c. $Co\Theta+K_2\Theta$ gave also ·2823 gr. $CoS\Theta_4$=16·75 p. c. $Co\Theta$=18·54 p. c. $Co_2\Theta_3$.

·5453 gr. salt gave ·5110 gr. $Co_2K_65S\Theta_4$=48·69 p. c. $Co\Theta+K_2\Theta$ gave also ·1885 gr. $CoS\Theta_4$=16·73 p. c. $Co\Theta$=18·51 p. c. $Co_2\Theta_3$.

·6805 gr. salt gave ·6373 gr. $Co_2K_65SO_4$=48·66 p. c. $Co\Theta+K_2\Theta$ gave also ·2358 gr. $CoS\Theta_4$=16·77 p. c. $Co\Theta$=18·55 p. c. $Co_2\Theta_3$.

·3712 gr. salt gave ·3480 gr. $Co_2K_65S\Theta_4$=48·71 p. c. $Co\Theta+K_2\Theta$ gave also ·1297 gr. $CoS\Theta_4$=16·90 p. c. $Co\Theta$=18·71 p. c. $Co_2\Theta_3$.

With 1·5460 gr. salt, combustion-tube lost ·3033 gr., of which $CaCl_2$ tube took up ·0116=0·75 p. c. $H_2\Theta$ leaving ·2917 gr. =18·87 p. c. N=51·21 p. c. $N_2\Theta_3$.

Prep. No. 1.

$Co_2 6N\Theta_2 + 6(KN\Theta_2) + 4H_2\Theta$.

	Theor. p. cts.	Found p. cts.
$Co_2\Theta_3$	17·00	17·45
$K_2\Theta$	28·94	29·00
$N_2\Theta_3$	46·69	45·21
$H_2\Theta$	7·37	6·99

Prep. No. 2.

$Co_2 6N\Theta_2 + 6(KN\Theta_2) + 3H_2\Theta$.

Theor. p. cts.	Found p. cts.
17·32	17·77
29·48	29·70
47·57	47·22
5·63	5·43

Prep. No. 3.

$Co_2 6N\Theta_2 + 6(KN\Theta_2) + 2H_2\Theta$.

	Theor. p. cts.	Found p. cts.
$Co_2\Theta_3$	17·65	17·96
$K_2\Theta$	30·04	31·41*
$N_2\Theta_3$	48·48	47·87
$H_2\Theta$	3·83	4·15

Prep. No. 4 *and* 5.

$Co_2 6N\Theta_2 + 6(KN\Theta_2) + 3H_2\Theta$.

Theor. p. cts.	Found p. cts.	
17·99	18·20	18·55
30·63	30·81	30·61
49·43	49·24	49·43
1·95	3·64†	3·92†

Prep. No. 6.

$Co_2 6N\Theta_2 + 6(KN\Theta_2)$.

	Theor. p. cts.	Found p. cts.
$Co_2\Theta_3$	18·35	18·58
$K_2\Theta$	31·24	31·90
$N_2\Theta_3$	50·41	51·21
$H_2\Theta$	0·—	0·75

It will be seen that, while the general coincidence is well sustained, there are several decided deviations. We can only call attention to certain facts in explanation 1st. We probably have in some of these preparations, mixtures of the salts of different degrees of hydration. 2nd. The salt cannot be purified by re-crystallization. 3rd. The acetate of potash with which the salt is first washed is, as Rose‡ remarks, only removed with difficulty by the alcohol.

Having formed from these analytical results our conclusions, let us see if we can find any confirmation of them from other sources. Lang§ states that although the corresponding soda and ammonia salts were probably formed, yet they could not be obtained on account of their solubility. By using a strong $NaN\Theta_2$ solution,‖ I succeeded in obtaining the new soda com-

* Acetate of potash probably not all washed out by alcohol.

† Unnaccountably high.

‡ Anal. Ch. sechste auflage, Zweiter Band, p. 128.

§ Jr. pr. Ch., lxxxvii, 303.

‖ The $KN\Theta_2$ and $NaN\Theta_2$ solutions used in this work were prepared as follows: 1 part of nitre and 2 parts of lead were fused together after Stromeyer's well-known method. After the complete oxydation of the lead, the residue was boiled several times with water. The solution was then filtered to remove the undissolved litharge. Into the filtrate which contained more or less free alkali, the red gas evolved from nitric acid and sawdust was passed until a neutral reaction was obtained This red gas, however, does not consist of the oxyds of nitrogen alone; it also contains some carbonic acid. This throws down as carbonate of lead, the litharge which pounds, which I am about to describe. To a solution of $CoCl_2$, which had been boiled and then acidified with acetic acid I added an excess of $NaNO_2$ solution. The mixture instantly became of a dark color and a yellowish-brown salt began to form, with brisk evolution of nitric oxyd. After some hours, when the evolution of gas was progressing but slowly, I added some more of the $NaNO_2$ solution, testing also to assure myself that the solution was acid, and in a little while the solution began to assume a yellowish color, and I found a clear yellow salt depositing. This led to the conjecture that there were two distinct soda salts. I accordingly sought to obtain them distinct for analysis. This I found to be difficult. The brown salt I readily got almost pure, but succeeded only partially in obtaining the yellow one distinct. The brown salt continues to form, to a greater or less extent, even after the formation of the yellow one has begun. The preparations were all washed with acetate of soda, which was displaced with alcohol. From analyses of them, and from other and subsequent results, I am led to consider them as salts analogous to Fischer's salt and differing from each other in the number of atoms of $NaNO_2$ in combination with the $Co_2 6NO_2$. The brown salt I would call a *di-sodio-cobaltic-nitrite*, and the yellow one a *tri-sodio-cobaltic-nitrite*, giving them respectively the formulas:

$Co_2 6NO_2 + 4(NaNO_2) + H_2O$. And $Co_2 6NO_2 + 6(NaNO_2) + H_2O$

The following are the analytical results:

Brown Salt. 1st Preparation.

·5400 gr. salt gave ·4676 gr. $Co_2Na_4 4SO_4$=39·94 p. c. $CoO + Na_2O$ also gave ·2374 gr. $CoSO_4$=21·27 p. c. CoO=23·54 p. c. Co_2O_3.

·5866 gr. salt gave ·5041 gr. $Co_2Na_4 4SO_4$=39·64 p. c. $CoO + Na_2O$ also gave ·2615 gr. $CoSO_4$=21·57 p. c. CoO=23·87 p. c. Co_2O_3.

Brown Salt. 2nd Preparation.

·5602 gr. salt gave ·4805 gr. $Co_2Na_4 4SO_4$=39·57 p. c. $CoO + Na_2O$ also gave ·2425 gr. $CoSO_4$=20·95 p. c. CoO=23·18 p. c. Co_2O_3.

·4671 gr. salt gave ·4027 gr. $Co_2Na_4 4SO_4$=39·77 p. c. $CoO + Na_2O$ also gave ·2026 gr. $CoSO_4$=20·99 p. c. CoO=23·23 p. c. Co_2O_3.

With 1·7054 gr. salt, combustion-tube lost ·4476 gr., of which $CaCl_2$ tube took up ·1156 gr.=6·78 p. c. H_2O leaving ·2920 gr.=17·12 p. c. N.=46·47 p. c. N_2O_3.

had gone into solution. It is now filtered and the filtrate evaporated to an oily consistency, when the saltpetre in it will almost all crystallize out. We filter it again and if we wish it still purer we can give it the treatment with alcohol described by Hampe (Ann. Ch. u. Ph., 125, 335). This frees it completely from saltpetre and concentrates it.

With 1·8558 gr. salt, combustion-tube lost ·4476 gr., of which $\mathrm{CaCl_2}$ tube took up ·1216=6·55 p. c. $\mathrm{H_2\Theta}$ leaving ·3260 gr. =17·56 p. c. N.=47·67 p. c. $\mathrm{N_2\Theta_3}$.

Yellow Salt. 1st Preparation.

·6342 gr. salt gave ·5448 gr. $\mathrm{Co_2Na_6 5S\Theta_4}$=39·22 p. c. $\mathrm{Co\Theta+Na_2\Theta}$ the Co determination was lost.

·5805 gr. salt gave ·4994 gr. $\mathrm{Co_2Na_6 5S\Theta_4}$=39·28 p. c. $\mathrm{Co\Theta+Na_2\Theta}$ also gave ·2431 gr. $\mathrm{CoS\Theta_4}$=18·55 p. c. $\mathrm{Co\Theta}$=20·53 p. c. $\mathrm{Co_2\Theta_3}$.

Yellow Salt. 2nd Preparation.

·4197 gr. salt gave ·3700 gr. $\mathrm{Co_2Na_6 5S\Theta_4}$=40·25 p. c. $\mathrm{Co\Theta+Na_2\Theta}$ also gave ·1723 gr. $\mathrm{CoS\Theta_4}$=19·86 p. c. $\mathrm{Co\Theta}$=21·98 p. c. $\mathrm{Co_2\Theta_3}$.

·4873 gr. salt gave ·4291 gr. $\mathrm{Co_2Na_6 5S\Theta_4}$=40·20 p. c. $\mathrm{Co\Theta+Na_2\Theta}$ also gave ·2012 gr. $\mathrm{CoS\Theta_4}$=19·98 p. c. $\mathrm{Co\Theta}$=22·11 p. c. $\mathrm{Co_2\Theta_3}$.

Yellow Salt. 3rd Preparation.

·8554 gr. salt gave ·7354 gr. $\mathrm{Co_2Na_6 5S\Theta_4}$=39·25 p. c. $\mathrm{Co\Theta+Na_2\Theta}$ also gave ·3543 gr. $\mathrm{CoS\Theta_4}$=20·04 $\mathrm{Co\Theta}$=22·18 p. c. $\mathrm{Co_2\Theta_3}$.

	$\mathrm{Co_26N\Theta_2+4(NaN\Theta_2)+H_2\Theta}$.			$\mathrm{Co_26N\Theta_2+6(NaN\Theta_2)+H_2\Theta}$.			
	Theor. p. cts.	Found p. cts.		Theor. p. cts.	Found p. cts.		
$\mathrm{Co_2\Theta_3}$	—24·13	23·71	23·21	20·10	20·53	22·04	22·18
$\mathrm{Na_2\Theta}$	—18·02	18·37	18·70	22·52	20·70	20·31	19·21
$\mathrm{N_2\Theta_3}$	—55·23		47·07 (?)*	55·20			[20·54]
$\mathrm{H_2\Theta}$	— 2·62		6·66 (?)*	2·18			

Some error connected with the $\mathrm{CaCl_2}$ tube which I am entirely unable to account for has here caused an error. It will be observed that in each case the total loss of the combustion-tube is very nearly what the theor. per cent of $\mathrm{H_2\Theta+N}$ would demand, while the increase in the $\mathrm{CaCl_2}$ tube is out of all proportion. If we examine the results in the yellow salt, we see that all these preparations are more or less mixtures. The last preparation indeed might be put equally under the head of the 2-atom salt, the per cent in bracket showing the per cent $\mathrm{Na_2\Theta}$ calculated on the other formula. We are fortunately, however, not dependant solely on these analyses for our evidences of the existence of these two salts. On account of their partial solubility, we are enabled to obtain substitution compounds from them, which throw very strong light on the composition of the alkali-cobaltic nitrites. In one case, after the formation and filtering off of some of the brown salt, chlorid of luteocobalt was added to the wine-colored filtrate, which

* The found per centages of $\mathrm{N+H_2\Theta}$ in the brown salt is the average of two determinations.

probably held some of both salts in solution. The strong tendency which luteocobalt possesses to form double salts suggested to Dr. Gibbs that some results might be here obtained. A beautiful yellow crystalline salt formed and settled quite readily. I then prepared a considerable amount of it for analysis. It proved to be as good as insoluble in cold water, so that its washing was an easy matter. Its analysis shows very clearly that it was formed from the tri-sodio-cobaltic nitrite, or yellow soda salt, which existed in the solution, and that one atom of luteocobalt exactly replaces the three of $Na_2\Theta$, giving it the formula:

$$\bar{C}o_2, 6N\Theta_2 + \bar{C}o_2 12NH_3, 6N\Theta_2 + H_2\Theta.$$

The following are the analytical results:

·5627 gr. salt gave ·3471 gr. $\bar{C}oS\Theta_4 = 29{\cdot}85$ p. c. $\bar{C}o\Theta = 33{\cdot}03$ p. c. $\bar{C}o_2\Theta_3$.

·2867 gr. salt gave ·1770 gr. $\bar{C}oS\Theta_4 = 29{\cdot}87$ p. c. $\bar{C}o\Theta = 33{\cdot}06$ p. c. $\bar{C}o_2\Theta_3$.

·5834 gr. salt gave 176·88 cc. nitrogen at 3° and 661·29 mm. = 32·79 p. c. N. = 19·91 p. c. NH_3 and 44·50 p. c. $N_2\Theta_3$.

1·0866 gr. salt gave with $\bar{C}u + \bar{C}u\Theta + PbCr\Theta_4$ ·3745 gr. = 34·46 p. c. $H_2\Theta = 32{\cdot}09$ p. c. from $NH_3 + 2{\cdot}37$ p. c. $H_2\Theta$.

$$\bar{C}o_2, 6N\Theta_2 + \bar{C}o_2 12NH_3, 6N\Theta_2 + H_2\Theta.$$

	Theor. p. cts.	Found p. cts.
$\bar{C}o_2\Theta_3$	32·87	33·04
NH_3	—20·20	19·91
$N_2\Theta_3$	—45·15	44·50
$H_2\Theta$	— 1·78	2·37

I now tried chlorid of purpureo-cobalt upon some of the same solution and got a roseo-cobalt compound, exactly analogous to that of luteocobalt, its formula being—

$$\bar{C}o_2 6N\Theta_2 + \bar{C}o_2 10NH_3 6N\Theta_2 + H_2\Theta.$$

The following were the analytical results:

·3186 gr. salt gave ·1974 gr. $\bar{C}oS\Theta_4 = 29{\cdot}98$ p. c. $\bar{C}o\Theta = 33{\cdot}18$ p. c. $\bar{C}o_2\Theta_3$.

$$\bar{C}o_2, 6N\Theta_2 + \bar{C}o_2 10NH_3, 6N\Theta_2 + H_2\Theta.$$

	Theor. p. ct.	Found p. ct.
$\bar{C}o_2\Theta_3$	—34·02	33·18

This salt is not nearly as insoluble, however, as the luteocobalt salt and but a little of it could be obtained. At first I got it as a yellow and very crystalline salt on the sides of the beaker, after standing some little time. The crystals examined under the microscope were beautifully defined monoclinic prisms with terminal planes. The portion I analyzed had more of the color of the salts of roseo-cobalt and showed under the microscope a star-shaped aggregation of small crystals.

I also formed in the soda-salt solution a yellowish xantho-cobalt compound having probably an analogous constitution but did not get enough of it to analyze. Examined under the microscope, the crystals were seen to be of a peculiar cup-shaped appearance and quite large and pointed.

The ammonium salts were next examined. That one at least existed had been found by Gibbs and Genth,* although it had not been analyzed by them. Erdmann† had, however, formed an ammonium salt exactly corresponding to Fischer's salt. I succeeded in forming this and another, the two exactly corresponding in constitution to the two soda salts. The circumstances under which the different salts form I am not able, however, to state at all positively, except that in forming the 3-atom salt I had more concentrated $ЄoCl_2$ and $NH_4NΘ_2$ solutions. They are both bright yellow and could not be distinguished by their color. We may term them the *di-ammonio-cobaltic nitrite* and the *tri-ammonio-cobaltic nitrite*, their formulas being respectively

$$Єo_2 6NΘ_2 + 4(NH_4NΘ_2) + 2H_2Θ$$

and

$$Єo_2 6NΘ_2 + 6(NH_4NΘ_2) + 2H_2Θ.$$

The following were the analytical results:

Two-atom Salt.

·4495 gr. salt gave ·2022 gr. $ЄoSΘ_4$=21·77 p. c. ЄoΘ=24·09 p. c. $Єo_2Θ_3$.

Three-atom Salt.

·2992 gr. salt gave ·1145 gr. $ЄoSΘ_4$=18·53 p. c. ЄoΘ=20·51 p. c. $Єo_2Θ_3$.

·4169 gr. salt gave ·1602 gr. $ЄoSΘ_4$=18·59 p. c. ЄoΘ=20·58 p. c. $Єo_2Θ_3$.

	$Єo_2 6NΘ_2 + 4(NH_4NΘ_2) + 2H_2Θ$.		$Єo_2 6NΘ_2 + 6(NH_4NΘ_2) + 2H_2Θ$.	
	Theor. pr. ct.	Found pr. ct.	Theor. pr. ct.	Found pr. ct.
$Єo_2Θ_3$—	24·20	24·09	20·39	20·55

Lang is more nearly right in the case of these ammonia compounds than in regard to the soda salts, they being much more soluble. I was unable, however, to obtain any substitution compounds. With this additional light we are now prepared to draw some conclusions. We find that our luteocobalt and roseocobalt compounds are exactly analogous to the cobalticyanids of luteocobalt and roseocobalt formed by Gibbs and Genth,‡ the only difference being that the monatomic radical $NΘ_2$ here replaces the monatomic radical Cy. This I think

* Researches on Ammonia cobalt bases, p. 48. † Jour. Pr. Ch., xcvii, 405.
‡ Researches on Ammonia cobalt bases, pp. 40, and 18.

gives us a very strong argument in favor of the exact analogy of the 3-atom soda salt and with it of Fischer's salt, to the cobalticyanid of potassium, from which the salts of Gibbs and Genth were formed. With this view of these salts, we are able to discern yet other analogies. Iridium forms a number of sesquioxyd salts very similar to those of cobalt. We have, indeed, two double chlorids of iridium, exactly analogous to the 2-atom and 3-atom soda or ammonia salts. Their formulas are

$$Ir_2Cl_6+4KCl \text{ and } Ir_2Cl_6+6KCl$$

in which we should expect monatomic Cl to be exactly replaceable by monatomic $N\Theta$, and so we find that it is. Dr. Gibbs has discovered an iridium salt, having the formula

$$Ir_26N\Theta_2+6(KN\Theta_2)+2H_2\Theta,$$

an exact analogue of Fischer's salt. Lang* also has discovered a rhodium salt, whose formula $Rh_26N\Theta_2+6(KN\Theta_2)$ is precisely analogous. If we place together for a moment the three salts in question, their identity of constitution becomes apparent.

$Ir_2\Theta_3$, $3N_2\Theta_3+3(K_2\Theta, N_2\Theta_3)$ or $Ir_26N\Theta_2+6(KN\Theta_2)$—Gibbs.
$Rh_2\Theta_3$, $3N_2\Theta_3+3(K_2\Theta, N_2\Theta_3)$ or $Rh_26N\Theta_2+6(KN\Theta_2)$—Lang.
$Co_2\Theta_3$, $3N_2\Theta_3+3(K_2\Theta, N\ \Theta_3)$ or $Co_26N\Theta_2+6(KN\Theta_2)$—Sadtler.

If, therefore, we are to place any dependence at all upon analogy, the universal occurrence of the hexatomic Co_2 atom in all our compounds, is what we should expect, a priori. The analyses of the series of salts I think fully confirms this expectation.

I have now to discuss some related compounds—those formed in neutral solutions. Erdmann first pointed out the distinction between these and the normal Fischer's salt. He obtained and analyzed a yellow "neutral salt." I obtained one corresponding to this, and one of a different ratio. By adding a somewhat dilute solution of $KN\Theta_2$ to a warm solution of $CoCl_2$, I obtained a highly crystalline precipitate, which was shortly followed by a somewhat crystalline greenish salt, which was again followed after some time by a yellowish precipitate, with little or no crystalline character. The appearances were indicative of the successive formation of three protoxyd compounds. This however, I found was not the case. The black precipitate under the microscope was seen to consist of beautifully defined cubes of a very dark green color, and the green precipitate was seen to consist of similar cubes, though much smaller. Analysis afterward proved them to be the same salt in different states of aggregation. On adding a warm concentrated solution of $KN\Theta_2$, however, to a warm concentrated solution of $CoCl_2$ nothing is formed but a flocculent yellow precipitate, which appears to be the same as that which I formed over mercury in the eudiometer tube. The formulas of these salts appear to be as

* Royal Swedish Acad. Trans., 1864.

follows. For the black or green salt $2(Co2N\Theta_2)+2(KN\Theta_2)+H_2\Theta$ and for the yellow salt $Co2N\Theta_2+2(KN\Theta_2)+H_2\Theta$, and the first may be termed a *potassio-dicobaltous nitrite* and the second a *potassio-mono-cobaltous nitrite.* Appended are the analytical results.

Prep. No. 1.—*Black Salt*, very crystalline.

·5421 gr. salt gave ·5421 gr. $Co_2K_23S\Theta_4$=50·43 p. c. $Co\Theta+K_2\Theta$
also gave ·3425 gr. $CoS\Theta_4$=30·57 p. c. $Co\Theta$.
·7341 gr. salt gave ·7361 gr. $Co_2K_23S\Theta_4$=50·57 p. c. $Co\Theta+K_2\Theta$
also gave ·4662 gr. $CoS\Theta_4$=30·73 p. c. $Co\Theta$.

Prep. No. 2.—*Green Salt* (had not been washed for analysis.

·3003 gr. salt gave ·3063 gr. $Co_2K_23S\Theta_4$=51·44 p. c. $Co\Theta+K_2\Theta$
also gave ·1846 gr. $CoS\Theta_4$=29·74 p. c. $Co\Theta$.
·3221 gr. salt gave ·3286 gr. $Co_2K_23S\Theta_4$=51·45 p. c. $Co\Theta+K_2\Theta$
also gave ·1971 gr. $CoS\Theta_4$=29·61 p. c. $Co\Theta$.

Prep. No. 3.—*Black and Green Salts mixed*, very crystalline.

·6942 gr. salt gave ·6978 gr. $Co_2K\ 3S\Theta_4$=50·70 p. c. $Co\Theta+_2K\Theta$
also gave ·4410 gr. $CoS\Theta_4$=30·74 p. c. $Co\Theta$.
·4713 gr. salt gave ·4730 gr. $Co_2K_23S\Theta_4$=50·62 p. c. $Co\Theta=K_2\Theta$
also gave ·3004 gr. $CoS\Theta_4$=30·84 p. c. $Co\Theta$.

Prep. No. 1.—*Yellow Salt.*

·2702 gr. salt gave ·2631 gr. $CoK_22S\Theta_4$=50·05 p. c. $Co\Theta+K_2\Theta$
also gave ·1235 gr. $CoS\Theta_4$=22·12 p. c. $Co\Theta$.
·4615 gr. salt gave ·4497 gr. $CoK_22S\Theta_4$=50·08 p. c. $Co\Theta+K_2\Theta$
also gave ·2103 gr. $CoS\Theta_4$=22·05 p. c. $Co\Theta$.

$2(Co2N\Theta_2)+2(KN\Theta_2)+H_2\Theta$.				$Co2N\Theta_2+2(KN\Theta_2)+H_2\Theta$	
Theor. p. cts.	Found p. c. cts.			Theor. p. cts.	Found p. cts.
$Co\Theta$—30·60	30·65	29·67	30·79	22·11	22·08
$K_2\Theta$—19·22	19·85	21·78	19·87	27·77	27·09
$N_4\Theta$—46·51				44·80	
$H_2\Theta$— 3·67				5·31	

In looking over the analytical data of these analyses of protoxyd salts, we notice a striking similarity between the weights of salt taken and weights of double sulphates obtained. The explanation is very simple, and yet I believe there is involved in it a fact of importance. The similarity of weights is due to the similarity of atomic weights of $N_2\Theta_3$ and $S\Theta_3$ (76 and 80) with which the bases are combined. Now in none of the very many determinations made in the "acid salts," do we find such a similarity. On the contrary we find the weight of double sulphates to be invariably less than the weight of salt taken and in a fixed ratio. The explanation of this is that $Co_2\Theta_33N_2\Theta_3$ by digestion with $H_2S\Theta$ is converted into two atoms of neutral $CoS\Theta_4$ and becomes $2(CoS\Theta_4)$. $2Co\Theta, 2N_2\Theta_3$ simply assumes

SO_3 instead of N_2O_3 and becomes likewise $2(CoSO_4)$. The first loses and atom of NO_2 which the second does not. We have here a strong evidence of the totally different habitus of the Co atom in the "neutral" and in the "acid" salts.

Having now made a complete statement of all my analytical results in the case of Fischer's salt proper, as well as in this series of analogous and related compounds, which I have described in this connection, and noticed the conclusions to be drawn from them, before summing up my argument, I will examine how the results of Stromeyer, Erdmann and Braun compare with my own. In the first case I think the last argument drawn from the similarity of weights of double nitrite and double sulphate in the protoxyd salts and the difference of weights of double nitrite and double sulphate in the sesquioxyd salts, effectually precludes our assigning a formula like that of Stromeyer, in which $2(N_2O_3)$ combines with Co_2O_3, to the normal Fischer's salt. The salt Stromeyer analyzed was probably a mixture of "acid" and "neutral" salts, as he speaks of adding "a little acetic acid." It is easily seen that a mixture of the "acid salt" and the yellow "neutral salt" would give figures approximating to his. Erdmann's results correspond in the main to the analysis of my second preparation. The only difference then is that I have introduced a generalization, which I think my figures fully justify. With Braun's results, I am hardly able to make a comparison, as he made his preparation in a manner totally different from that followed by either Erdmann or myself. His formulas, as might be inferred from my statement of them in the beginning of this paper, I am still less able to accept.

To sum up briefly, the reasons for regarding Fischer's salt as a potassio-cobaltic nitrite, having the essential formula

$$Co_2 6NO_2 + 6(KNO) + aq. \text{ are—}$$

1st. The liberation of O at the moment of its formation and the rapidity with which, under these circumstances, the salt forms, would seem to justify the assumption.

2nd. The analyses of six distinct preparations sustain it.

3rd. The existence of corresponding sodic and ammonic salts is proved by analysis.

4th. The formation of substitution compounds exactly analogous to well known salts is proved by analysis.

5th. The analogy of Fischer's salt to double cyanids, chlorids and nitrites proved to contain a similar hexatomic atom.

6th. The difference of ratio between the weights in the protoxyd and sesquioxyd salts is marked and constant throughout.

Accepting these proofs, we will sum up with equal brevity the formulas of the salts analyzed on this view:—

Tri-potassio-cobaltic nitrite,	$Co_2 6NO_2 + 6(KNO_2) + aq.$
Di-sodio-cobaltic nitrite,	$Co_2 6NO_2 + 4(NaNO_2) + H_2O.$
Tri-sodio-cobaltic nitrite,	$Co_2 6NO_2 + 6(NaNO_2) + H_2O.$
Di-ammonio-cobaltic nitrite,	$Co_3 6NO_2 + 4(NH_4NO_2) + 2H_2O.$
Tri-ammonio-cobaltic nitrite,	$Co_2 6NO_2 + 6(NH_4NO_2) + 2H_2O.$
Luteocobaltio-cobaltic nitrite,	$Co_2 6NO_2 + Co_2 12NH_3, 6NO_2 + H_2O.$
Roseocobaltio-cobaltic nitrite,	$Co_2 6NO_2 + Co_2 10NH_2, 6NO_2 + H_2O.$
Xanthocobaltio-cobaltic nitrite,	
Potassio-dicobaltous nitrite,	$2(Co 2NO_2) + 2(KNO_2) + H_2O.$
Potassio-monocobaltous nitrite,	$Co_2 NO_2 + 2(KNO_2) + H_2O.$

These it will be seen are capable of ready conversion into atomic formulas, thus: $Co_2^{vi}[K(NO_2)_2]6$ and $Co_2^{vi}[(Na(NO_2)_2)_2 (NO_2)_4]$ and so on.

In the course of my examination of these salts, I had an opportunity of comparing the relative merits of the different analytical methods employed. A brief statement in regard to them may be of some value.

1st. Determination of Co and K. The double sulphate method already alluded to, was first proposed by Gibbs and Genth,* and I find it to give extremely close results. Sulphuric acid is added to the weighed portion of the salt in a porcelain crucible, which is then heated carefully, either by a ring gas burner from above, or by radiation while supported in a sheet-iron crucible. After the nitrous acid is all driven off with most of the excess of sulphuric acid, the sulphates begin to fuse and as the last trace of sulphuric acid goes off, they pass into calm fusion. They will then bear a very considerable increase of heat without farther decomposition. I found this method capable of extension to both the soda salts, as well as to the protoxyd salts, the double sulphates formed having of course a constitution depending upon the proportion of the bases in the original salts. The soda sulphates did not appear, however, to possess as perfect a fusibility as the double potash sulphate from Fischer's salt, while the double sulphates from the protoxyd potash salts were also less fusible, in proportion to their greater ratio of Co. I give an instance in proof of the accuracy of this method. Four determinations of $CoO + K_2O$ were made in preparation No. 6 of Fischer's salt in the manner described. The percentages of double oxyds were 48·71, 48·69, 48·66, 48·71. This method was tried by Gauhe† without obtaining good results. Several points are to be noticed however. The salt in which Gauhe sought to verify the composition of the double sulphate was plainly a mixture of "acid" and "neutral" salt. He says, "after some days small amounts deposited." This was before Erdmann's paper had appeared.

* Researches on Ammonia cobalt bases, p. 49.

† Zeitsch. Anal. Ch., iv, p. 56.

Again, Gauhe will find that Gibbs and Genth never even mentioned the use of $(NH_4)_2CO_3$ in this connection, so that his experiments were plainly made under different conditions from those proposed.

2d. Determination of Co. I prefer to determine Co as neutral $CoS\Theta_4$. We have the advantage here of determining the Co in the form of a compound of higher atomic weight, thus lessening our errors of analysis. The cobalt is precipitated from the solution of the double sulphates as CoS, washed with hot sulphid of ammonium water, dried and roasted and then converted into sulphate with the aid of aqua regia and sulphuric acid. The results are good, although not so exact as in the case of the fusible double sulphates. I also determined Co as metal by H after its precipitation as hydrated oxyd by Cl and acetate of soda, a method proposed by Popp.* Instead of Cl I found it far more convenient in practice to use a strong solution of $Cl_2\Theta_4$, which is a powerful oxydizing agent, and as it can be kept, becomes a useful laboratory reagent. This method, however, does not always give good results, on account of the difficulty of washing the hydrated $Co_2\Theta_3$ till free from alkali.

3d. Determination of the N. This was done, first by the modification of Bunsen's† method proposed by Dr. W. Gibbs,‡ which space will not permit me to give in detail. The reader is therefore referred to the original paper. Suffice it to say, that for nitrates and nitrites to which it is applicable, it is an excellent method. The loss of the combustion-tube can be nothing but N and $H_2\Theta$. If, therefore, the $CaCl_2$ tube retains the $H_2\Theta$ accurately, the remainder is N. Whether, therefore, the $H_2\Theta$ is accurate, or high from hygroscopic moisture, the nitrogen must be accurate, being subject to no source of error.

The nitrogen was also determined by volume, using the Sprengel-pump. This method was first proposed by Frankland§ for nitrogen in analyses of potable waters, but he did not apply it then to organic analysis. The application, however, had been made in this laboratory by Dr. Gibbs some months before Dr. Frankland's paper was received. A vacuum is first made in the combustion-tube by means of the mercury-pump. The delivery-tube from the pump is then connected with a Simpson's receiver and the vacuum destroyed by heating some $C\Theta_2$ placed in the anterior portion of the tube. Any excess of $C\Theta_2$ is absorbed by the $KH\Theta$ solution in the receiver. The combustion is now made. A final vacuum is then obtained by the pump and the receiver disconnected. After a short time the gas is transferred to a eudiometer-tube and measured according to the methods of gas-analysis. The results are generally good, but depend upon

* Ann. Ch. u. Ph., 131, 363.
† Ann. Ch. u. Ph., 72, 40.
‡ This Jour., xxxvii, 350.
§ Jour. Ch. Soc., 1868, p. 90.

the vacuum obtained at the beginning and end, on the perfect combustion, and on the perfect transfer of the gas.

In conclusion I would present my grateful acknowledgments to Dr. W. Gibbs, to whose kindness I am indebted for the selection of my subject, for the use of materials, and for many valuable suggestions during the prosecution of my work.

Cambridge, Jan., 1870.

ART. XXV.—*Notice of some Fossil Birds, from the Cretaceous and Tertiary Formations of the United States;* by O. C. MARSH, Professor of Paleontology in Yale College.

The remains of Birds described from European rocks are at present limited in the Mesozoic to the famous *Archæopteryx* of the Jurassic, and apparently a single species only from the Cretaceous; but in the Tertiary period, and especially in the Miocene and Pliocene, this class was very fully represented by many of the modern types, and numerous species have already been described by Owen, von Meyer, Gervais, Hébert, Lartet, Gaudry, A. Milne-Edwards, and other paleontologists. In this country, however, since the discovery that the three-toed foot-prints in the Connecticut river sandstone were probably all made by Dinosaurian reptiles, no species of birds have been included in our extinct fauna, as, with this apparent exception, none have been described from any North American strata. Recent explorations, however, have shown that remains of this class are not wanting in the later formations of the United States, and that the Cretaceous and Tertiary, especially, contain representatives of many interesting forms.

The bones of birds, as might naturally be expected, are usually the rarest of vertebrate fossils, particularly in marine deposits; but, fortunately, those parts of the skeleton most likely to be preserved are especially characteristic, so that even small portions not unfrequently admit of accurate determination, although their investigation is a work of considerable difficulty, even where ample material for comparison with recent species is available. The specimens briefly described in the present preliminary notice, although nearly all fragmentary, are in an excellent state of preservation; and most of them show strongly marked characters, which indicate at least the near affinities of the species they represent. If the interpretation of them here given be correct, they prove the existence, in this country, even before the close of the Mesozoic, of an interesting and varied group of aquatic birds, and suggest for this period a very rich avine fauna.

Remains of Cretaceous Birds.

Among the fossils under consideration are specimens indicating five species of Cretaceous birds, the remains of which were found in the greensand of New Jersey, and with a single exception in the middle marl bed. The specimens are all mineralized, and in the same state of preservation as the bones of the extinct reptiles which occur with them in these deposits; and hence are readily distinguished from the remains of Post-tertiary and recent birds, which have occasionally been found near the surface in the greensand excavations of that region. In most instances, moreover, a record of the discovery places the geological horizon of the present fossils beyond a doubt.

Laornis Edvardsianus Marsh, gen. et sp. nov.

The most interesting, in many respects, of the specimens from the Cretaceous is a portion of the shaft and distal extremity of a left tibia, which indicates a species, apparently of a swimming bird, nearly as large as the common wild swan (*Cygnus Americanus* Sharpless). The specimen is well preserved, and shows that the tibia, when entire, was of medium length, and quite robust. The condyles of the distal end are broader anteriorily than deep, the inner condyle being more prominent in front, and the outer one projecting somewhat farther behind. The inter-condyloid space is wider than either condyle. The supratendinal bridge—one of the most characteristic portions of the skeleton, when present—is well ossified, and still uninjured. It is submedial in position, straight, transverse, of moderate width, and spans a deep and well defined canal, which was traversed by the extensor tendon of the toes. The outer margin of the canal is low and obtuse, as in most of the Gallinaceous birds. The inner margin is the more prominent, and just above the upper edge of the bridge it supports an elongated tubercle for the inner attachment of the oblique ligament. Opposite the bridge, on the other margin, there is a large triangular elevation, which is separated by a shallow transverse groove from the exterior condyle. To this prominence the outer end of the oblique ligament was attached. The outlet of the canal above the bridge is transversely elliptical in outline, and the one below more oval, and looking forward, and slightly outward. Just below this aperture, there is a shallow depression in the inter-condyloid space, similar in shape and position to that in the tibia of the wild goose (*Bernicla Canadensis* Boie), although rather deeper, and more oblique. The under trochlear surface is but slightly concave transversely, and has a faint median elevation, as in the tibia of the swan; but in the present specimen this is continued along the entire posterior surface, which is broad, with a slight, transverse concavity. On the lower surface of the inner condylar ridge there is a shallow notch, resembling in shape and position that in the tibia of some of the Gulls, especially the Herring Gull (*Larus argentatus* Brünn.). The ecto-condyloid surface is unusually circular in outline, and has, for the attachment of the external, articular ligament, a low tubercle, a little behind and below its central point. Just in front of this, there is a shallow groove extending directly upward. The ento-condyloid surface is moderately transverse, and has on its anterior portion, for the attachment of the internal ligament, a large irregular tubercle, which is connected by a low ridge with the prominent inner margin of the tendinal canal. A portion of the fibular ridge remains on the upper part of the specimen, and a faint indication of its continuation can be traced nearly to the ecto-condyloid surface, where it passes into a small, acute, elongated tubercle, which is just outside of the triangular prominence, already mentioned. Between these two elevations, there is a deep groove for the tendon of the short tibial muscle, and in its inner margin a small elongated foramen, leading obliquely downward and inward.

The portion of the shaft preserved is robust, and somewhat flattened in an antero-posterior direction. In the lower fourth of the bone, the transverse diameter gradually increases, and reaches its maximum at the extremity of the distal condyles. The shaft curves forward slightly just where it begins to expand above the lower condyles, closely resembling in this respect the tibia of the turkey; and it has at this point little of the marked inward curvature characteristic of the swimming birds, but is so straight, that its median plane, if continued, would divide the trochlear surface nearly equally.

The dimensions of the specimen are as follows:—

Length of portion preserved,	70·mm.
Width of condyles in front,	23·
Depth of outer condyle,	19·1
Width of bridge at center,	5·2
Transverse diameter of upper outlet,	5·
Transverse diameter of lower outlet,	4·4
Transverse diameter of shaft where broken,	11·8
Antero-posterior diameter of shaft where broken,	9·6

A consideration of the characteristic points of this interesting fossil leads to the conclusion that it should be placed in the order *Natatores*, but additional remains will probably be required to determine its exact affinities. It shows a strong resemblance in several respects to the *Lamellirostres*, and also to the *Longipennes*, but differs essentially from the typical forms of both these groups. For the extinct genus evidently represented by this specimen the name *Laornis** is proposed. The

* Λᾶας, *stone*, and Ὄρνις, *bird*.

species may very justly be named *Laornis Edvardsianus*, in honor of M. Alphonse Milne-Edwards, of Paris, whose great work on Fossil Birds, now in course of publication, promises to place this hitherto neglected branch of paleontology on a firm foundation.*

This unique specimen was found in the greensand of the upper, Cretaceous marl bed, at Birmingham, New Jersey, in the pits of the Pemberton Marl Company, and was presented to the Museum of Yale College by the superintendent, J. C. Gaskill, Esq.

Palæotringa littoralis Marsh, gen. et sp. nov.

The present collection contains, also, some remains of wading birds from the Cretaceous, and among them are specimens indicating two species, apparently belonging to the *Grallæ*. Each of these is represented by a portion of the shaft, and the lower extremity of a left tibia, and probably by some other fragmentary, but less characteristic parts of the skeleton. The tibia of the larger species resembles in size and general form that of the European Curlew (*Numenius arquata* Linn.). The condyles of the distal end are expanded anteriorly, but in their posterior extension continue upward as acute, prominent ridges. The inner condyle is somewhat narrower than the outer. The intercondyloid space is smooth, with the exception of a faint transverse groove, and is wider than either condyle. The trochlear surface is broad, slightly concave transversely, and its median portion nearly flat, especially at the extremity. Its upper, posterior surface projects slightly beyond the face of the adjoining shaft. The ecto-condyloid surface is smooth, and somewhat concave. The supratendinal bridge is narrow, very thin, transverse, and has its outer edge on the median line. The tendinal canal is very broad and deep, and its floor nearly flat. In its general features it resembles the canal of the Herring, or Silvery Gull. The aperture below the bridge is oval in outline, and looks forward, and slightly inward and downward. On the outer margin of the canal, just above the exterior condyle, there is a triangular rugose surface, to which the oblique ligament was apparently attached. This surface projects outward, so as to produce a slight swelling at this point on the side of the shaft. The interior margin of the canal is the more acute, and just above the bridge has on its inner edge a small elongated and inflected tubercle for the attachment of the upper end of the oblique ligament.

The shaft of the tibia is slender, and has its narrowest part at the beginning of the lowest fourth, or a little above where the margins of the tendinal canal begin. From this point

* Recherches sur les Oiseaux Fossiles de la France. 4to. Paris, 1867–70.

downward, the shaft curves slightly forward, and also expands transversely, but much more gradually than in most wading birds. The lower half of the tibia is unusually flat in front, and very convex behind. A transverse section of the broken end is broadly oval.

The admeasurements of this tibia are as follows:—

Length of portion preserved, - - - -	43·5mm.
Width of condyles in front, - - - - -	9·7
Depth of outer condyle, - - - - -	8·6
Width of bridge at center, - - - - -	1·6
Transverse diameter of upper outlet, - -	2·
Transverse diameter of lower outlet, - -	1·9
Transverse diameter of shaft where broken, -	4·7
Antero-posterior diameter of shaft where broken,	3·8

The remains on which this species is established are from the Cretaceous greensand of the middle marl bed. They were discovered by Nicholas Waln, Esq., in his marl pits, at Hornerstown, New Jersey, and by him presented to the Museum of Yale College.

Palæotringa vetus Marsh, sp. nov.

The present species is indicated by the lower portion of a right tibia, which is of peculiar interest, as it apparently was the first fossil bird-bone discovered in this country. It is mentioned by Dr. Morton in his Synopsis, as "the tibia of a bird belonging to the genus *Scolopax;*"* and subsequently by Dr. Harlan, who regarded it as the femur of a bird allied to the same genus.† The specimen has since remained in the collection of the Academy of Natural Sciences in Philadelphia, but no description of it has been published, probably owing to the fact that it has generally been regarded as a recent species, accidentally introduced into the deposit where found. It is, however, thoroughly fossilized, and in precisely the same state of preservation as the remains of birds, since discovered in the same region, which are known to be of Cretaceous age, and hence its antiquity cannot now be fairly called in question.

This specimen indicates a species about half the size of *P. littoralis*, or about as large as the Hudsonian Godwit (*Limosa Hudsonica* Swain.). In general form and proportions it closely resembles the tibia just described. This is especially evident in the very gradual, transverse expansion of the lower end of the tibia; and in the broad concave trochlear surface, with no indications of a median elevation, or of the peculiar flattening of the inferior surface, which is seen in many of the Snipe family.

* Synopsis of the Organic Remains of the Cretaceous of the U. S., p. 32, Philadelphia, 1834.

† Medical and Physical Researches, p. 280, Philadelphia, 1835.

One of the most important differences between them, however, is in the supra-tendinal bridge, which in the present specimen is broader and stouter, and the outlet below looks more directly forward. The inter-condyloid space, also, has a distinct transverse depression, which is but faintly indicated in the former specimen. The rugose surface on the outer margin of the canal is here replaced by three tubercles, the largest of these, to which the oblique ligament was doubtless attached, being nearly opposite the bridge, and the other two above and outside of it. The anterior face of the tibia above the bridge is nearly flat, with a faint median rising, which throws the true tendinal canal against its inner margin. In the previous specimen this elevation does not exist, the corresponding space being transversely concave. The ecto-condyloid surface in this species is almost flat, with a slight elevation just below its central point. The ento-condyloid face is quite concave posteriorly, but near the middle of its anterior projection has a very small tubercle for the attachment of the lateral, articular ligament.

The principal dimensions of this tibia are as follows:—

Length of portion preserved, - - - -	18·5$^{mm.}$
Width of condyles in front, - - - - -	7·2
Depth of outer condyle, - - - - - -	4·9
Depth of inner condyle, - - - - -	6.6
Width of bridge at center, - - - - -	1·8
Transverse diameter of shaft where broken, -	3·4

The differences noted above between this specimen and the tibia of *P. littoralis* render it probable that additional remains would show that they belong to distinct genera; but for the present they may very properly be placed together in the genus *Palæotringa*,* and the present species be named *Palæotringa vetus*. The specimen, according to the authorities already cited, was found in the marl at Arneytown, New Jersey, which would imply that it was from the lowest, Cretaceous marl bed.

Telmatornis priscus Marsh, gen. et sp. nov.

The most important of the remains on which this species is founded is the lower half of a left humerus. The specimen is in perfect preservation, and, fortunately, a very characteristic part of the skeleton. In general appearance it resembles the humerus of some of the Rail family, and the species it represents is probably related to this group of birds. Evidence of this is seen in the unusual flattening of the lower part of the shaft and distal extremity; in the small articular condyles; in the diminutive protuberance for the attachment of the extensor muscle of the hand; and in the oval impression of the anterior brachial muscle. The latter has, however, in this

*Παλαιός, *ancient*, and Τρύγγας, *a shore bird*, mentioned by Aristotle.

specimen a more oblique position than in most of the *Rallidæ*. It resembles the corresponding impression in the woodcock, (*Philohela minor* Gray), but is situated higher up, and its superior margin is less distinctly defined. The distal end of this humerus resembles in its main features that of the Green Heron (*Butorides virescens* Bonap.), but differs widely from it in being much more compressed, and in having the imprint of the anterior brachial muscle much shorter, and more oblique.

The most important dimensions of this humerus are as follows:

Length of specimen preserved, - -	25·mm.
Vertical diameter of distal end, - -	11·2
Transverse diameter through radial condyle,	5·6
Depth of shaft where broken, - - -	4·4
Transverse diameter of shaft where broken, -	3·6
Length of impression of anterior brachial muscle,	5·8

These remains apparently indicate a genus of birds distinct from any yet described, for which the name *Telmatornis** is proposed. The present species, which was about the size of the King Rail (*Rallus elegans* Aud.), may be called *Telmatornis priscus*. The remains of the species at present known were found in the Cretaceous greensand of the middle marl bed, in pits of the Cream Ridge Marl Company, near Hornerstown, New Jersey, and were presented to the Museum of Yale College by John G. Meirs, Esq.

Telmatornis affinis Marsh, sp. nov.

This species is also based, essentially, on the lower portion of a right humerus, which was found at the same locality, and in the same stratum as the one just described. It closely resembles that specimen in most important particulars, but a careful comparison shows some points of difference which appear to justify its separation. The most apparent of these are the following:—The notch between the radial and ulnar condyles is somewhat deeper; the elongated tubercle, on the inner surface behind the notch, which confines the upper tendon of the triceps muscle, is larger; the impression of the anterior brachial muscle on the outer surface is higher up, and more shallow; and the epitrochlear elevation is more prominent. The specimen indicates, moreover, a species considerably smaller than the one mentioned above. Its principal measurements are as follows:—

Length of portion preserved, - - - - -	12·mm.
Vertical diameter of distal end, - - -	10·4
Transverse diameter through radial condyle, -	4·8
Vertical diameter of shaft where broken, -	5·6
Length of impression of anterior brachial muscle,	5·8

*Τέλμα, *marsh*, and Ὄρνις, *bird*.

These remains, also, were found by John G. Meirs, Esq., near Hornerstown, New Jersey, and by him presented to Yale College, in behalf of the Cream Ridge Marl Company.

Remains of Tertiary Birds.

The few remains of birds hitherto discovered in the Tertiary deposits of the United States naturally show a much closer resemblance to recent species than those from the Cretaceous. In the specimens examined by the writer during the present investigation, which include, it is believed, all the remains of importance known from the formation in this country, no characters implying genera distinct from existing birds are apparent, and some of the fossils seem to indicate species nearly related to those now living. Future discoveries, however, will doubtless disclose more important differences between faunæ so remote in time.

Puffinus Conradi Marsh, sp. nov.

The collection of the Academy of Natural Sciences in Philadelphia has for many years contained the distal half of a left humerus, and the lower portion of a right ulna, of an aquatic bird, which were discovered in the Miocene of Maryland by T. A. Conrad, Esq. A brief mention of these specimens, and of some other ornithic remains from the United States, has already been made by Professor Leidy,* but no description of them has yet been published. The specimens are so well preserved, and so characteristic, especially the humerus, that the affinities of the species they indicate can be determined with tolerable certainty. The most marked feature of the humerus is the transverse obliquity of its shaft and distal extremity. Both are much compressed, and so turned that the common plane of their longer diameters, instead of being nearly vertical, as in the brachium of most birds, is here highly inclined inward and downward. Among the other characters of importance may be mentioned, the unusually small size of the ulnar condyle, the very deep, oval impression for the attachment of the anterior brachial muscle, and the presence of an elongated, compressed apophysis, extending outward and upward from the exterior margin of the distal end, just in front of the radial condyle.

This humerus has the following dimensions:—

Length of portion preserved, - - -	49· mm.
Vertical diameter of distal extremity, -	13·2
Transverse diameter of radial condyle, - -	8·6
Transverse diameter of ulnar condyle, -	3·8
Length of impression of anterior brachial muscle,	5·6
Breadth of impression of anterior brachial muscle,	3·8
Longer diameter of shaft where broken, -	7·4
Shorter diameter of shaft where broken, - -	5·

* Proceedings Acad. Nat. Sciences, Philadelphia, 1866, p. 237.

A comparison of the present fossils with the corresponding parts of recent birds readily shows that the nearest allies of this extinct species must be sought in the Auk family, or among the Petrels; as it is only in these groups of birds, that the peculiar obliquity of the humerus, noticed above, exists. In the *Alcidæ*, however, this oblique compression is greater than in the present specimen. The latter has, moreover, on its outer edge above the radial condyle, the long, pointed projection, which is not seen in the Auks, although present in the Petrels, Gulls, and some of the wading birds. The difference in size between the ulnar and radial condyles, and the remarkably deep, oval, impression for the attachment of the anterior brachial muscle show unmistakably that this humerus belongs to one of the Shearwaters, and apparently should be placed in the genus *Puffinus*, with which it corresponds in all essential particulars. In size and general features it apparently resembles most nearly the brachium of the Cinereous Petrel (*Puffinus cinereus* Gmelin, sp.), of the Pacific coast, but there are some points of difference between them which clearly imply that the species are distinct. The flat apophysis on the outer edge of the distal extremity is in the fossil specimen more pointed; the impression, on the lower surface, of the anterior brachial muscle is deeper, and its outline more sharply defined, which is also the case with the small epicondylar depressions for the attachment of the muscles of the forearm. The bone indicates, moreover, a somewhat smaller bird.

The distal half of the right ulna, which was found with the humerus, apparently belonged to a bird of the same species, although its size would seem to indicate that it pertained to a smaller individual. The species represented by these remains may appropriately be named for its discoverer, T. A. Conrad, Esq., who has been so long and honorably identified with American paleontology.

Catarractes antiquus Marsh, sp. nov.

Among the other bird remains in the Museum of the Philadelphia Academy, is a very perfect left humerus, from Tarborough, Edgecombe county, North Carolina, which was presented by Dr. Booth. The geological position of the specimen is not definitely known, but its state of preservation and mineralization render it extremely probable, at least, that it is from the Tertiary deposits of that region. This humerus shows the same transverse obliquity which characterized the specimen just described, and so strongly resembles in other respects also the same bone in the Auks, that it should evidently be referred to that family. It approaches most nearly the humerus of the Guillemots, especially those now included in the genus *Catar-*

ractes, with which it appears to coincide in all important characters.

The principal dimensions of this humerus are as follows:

Total length, - - - - -	96·2mm.
Transverse diameter of proximal end, - -	21·
Vertical diameter of articular head, - -	14·2
Transverse diameter of articular head, - -	8·2
Vertical diameter of distal end, - - -	13·8
Longer diameter of shaft at center, - -	8·4
Shorter diameter of shaft at center, - -	5·

The present specimen shows so many points of resemblance to the humerus of the Thicked-billed Guillemot (*Catarractes lomvia* Linn.), that it will probably find in this species its nearest living representative. It indicates, however, a somewhat larger bird; and on carefully comparing the humeri of the two, some marked differences may be detected, which are quite sufficient to prove the species distinct. The most important of these are the following:—The head of the humerus in the fossil specimen is more obtusely rounded, both transversely and vertically; the two grooves, on the inner surface of the distal extremity, for the tendons of the triceps muscle, are of nearly equal width, the upper depression being somewhat wider than the other, but in *C. lomvia* Linn. the lower groove is much the broader; the ulnar condyle has, moreover, on its interior surface, a small obtuse tubercle, extending upward and inward, as in the humerus of the Great Auk (*Alca impennis* Linn.), while this projection is wanting in the Thicked-billed Guillemot; the lower face of the same condyle also differs from that of the latter species in forming a much narrower crescent; and in several minor points of structure a similar want of correspondence may be seen.

A right humerus, closely resembling the preceding specimen, and evidently belonging to the same genus, was presented to the Philadelphia Academy a few years since by Dr. A. C. Hamlin, who obtained it in the Post-tertiary clays, near Bangor, Maine, at a depth of forty-seven feet below the surface. It appears to be distinct from the above species, as well as from *C. lomvia* Linn., and will be described at an early day by the writer, in a paper now in course of preparation on the remains of some Quaternary birds.

Grus Haydeni Marsh, sp. nov.

The various explorations that have been made in the Tertiary deposits of the Upper Missouri region, so remarkably rich in mammalian remains, have, strange to say, brought to light but a single fragmentary specimen which can with certainty be referred to the class of birds; although the material collected there has been carefully examined for these fossils by several paleontologists. The only specimen hitherto detected was obtained by Dr. F. V. Hayden, several years since, in the later Tertiary beds of the Niobrara river. It is the distal extremity of a left tibia, one of the most common, and most characteristic parts of fossil birds, and indicates unmistakably a large species of the genus *Grus*, or Cranes. Although the specimen is somewhat injured, the most important parts are well preserved, and appear to exhibit good distinctive characters. The inner articular condyle is partially broken away, but was evidently much narrower than the other, and is continued far backward as a very sharp ridge. The outer condyle is somewhat flattened below, and its posterior extension projects beyond the surface of the shaft, although not so far as that of the inner condyle. The trochlear space is rather narrow, and has its deepest part inside of the median line. It is slightly concave transversely below, and deeply so posteriorly. The ecto-condyloid surface is concave, but has a low tubercle just in front of its central point. The supratendinal bridge is very broad, internal, transverse, and its surface is concave vertically. It spans a very narrow, but deep, internal canal. The lower outlet is subtriangular in outline, and looks obliquely forward and downward. The superior aperture is broadly oval, and the upper edge of the bridge is continued slightly above it on either side of the canal. The lower opening has its upper, straight margin slightly rounded, and its lower edge is formed by a sharp ridge, which separates it from the nearly flat intercondyloid space. External to this aperture is a prominent tubercle, which has its inner edge on the median line, and is connected above by a low ridge with the outer elongated tubercle for the attachment of the oblique ligament. A more prominent crest extends obliquely downward, and unites it with the external condyle. The inner margin of the canal is bounded by a well defined ridge, which, just above the bridge, is inflected over the edge. Externally, the margin of the canal is low, and indistinct. The groove for the tendon of the short tibial muscle is well defined, and bounded outwardly by a low ridge, which causes a projection on the exterior surface of the shaft.

The principal dimensions of this specimen are as follows:—

Length of portion preserved, - - -	31· mm.
Depth of external condyle, - -	19·2
Width of supratendinal bridge, - - -	7·2
Width of upper outlet, - - -	2·4
Width of lower outlet, - - -	3·6
Transverse diameter of shaft where broken, -	12·6
Antero-posterior diameter of shaft where broken,	8·2

This specimen, also, belongs to the Academy of Natural

Sciences in Philadelphia, and the extinct species it indicates is named for Dr. F. V. Hayden, whose explorations have added so much to our knowledge of the geology of the Upper Missouri, and Rocky Mountain regions.

Graculus Idahensis Marsh, sp. nov.

A collection of Tertiary fossils from Idaho, lately received by Professor Newberry, of Columbia College, contained the greater portion of the left metacarpal bone of an aquatic bird, which he has kindly loaned to the writer for examination. The specimen is in perfect preservation, and has such marked characters that it will evidently admit of at least approximate determination. Among the most prominent features of the fossil, at its proximal extremity, are, the great anterior projection of the radial apophysis, which is also elevated, and its superior portion considerably compressed; the deep anterior carpal fossa, which extends into the base of the carpal articular surface; the very deep and narrow posterior carpal fossa, which is auriform in outline, and extends obliquely inward and forward; and the internal and oblique position of the smaller metacarpal bone. The pisiform tubercle on the inner surface is of medium size, and its summit nearly flat. A sharp ridge extends from its anterior edge directly upward to the margin of the articular surface. The groove in front of this tubercle is very deep and broad. The fossa for the attachment of the inner lateral ligament of the wrist is also deep, and has, apparently, a small pneumatic opening near its center. The smaller branch of the metacarpal bone was slender, and but little separated from the larger one. Its outer edge at its superior attachment is on the median line, and opposite to this point, on the outer posterior edge of the large metacarpal, there is a small tubercle, to which the superior flexor muscle of the hand was attached. The lower extremity of the specimen has, unfortunately, been lost.

The principal dimensions of this metacarpal bone are as follows:—

Length of portion preserved, - - - -	45·mm·
Transverse diameter of proximal extremity, -	16·2
Diameter through pisiform tubercle, - - -	8·1
Width of carpal articular surface, - - -	7·2
Length of radial apophysis, - - - -	12·
Distance from inner superior edge to union of metacarpals, - - - - - - - -	18·6
Greater diameter of large shaft where broken,	5·4

The species represented by this fossil appears to have been related to the Cormorants, and may be placed provisionally in the genus *Graculus;* the metacarpal of which the present specimen resembles in nearly all important particulars. The most marked difference between them is the presence in the latter of the anterior carpal fossa. This interesting specimen, the only fossil bird bone yet found west of the Rocky Mountains, is from a fresh-water Tertiary deposit, probably of Pliocene age, on Castle Creek, Idaho Territory.

In addition to the acknowledgments made in the course of the present article, the writer desires, in conclusion, to express his grateful thanks to Professor Joseph Leidy, of Philadelphia, who generously placed in his hands for examination the various bird remains already mentioned as belonging to the Academy of Natural Sciences in that city. A more complete description, with illustrations, of all the remains here briefly noticed, and a determination of their nearer relations to living species, as well as the conclusions their discovery suggests, are reserved for a future communication.

Yale College, New Haven, Conn., Feb. 1st, 1870.

ART. XXVI.—*Contributions to Zoölogy from the Museum of Yale College.* No. VI.—*Descriptions of Shells from the Gulf of California;* by A. E. VERRILL.

HAVING in preparation faunal catalogues of the extensive collections of mollusca in the Museum of Yale College, collected in the Gulf of California by Capt. J. Pedersen, and at Panama, San Salvador, Peru, and other localities on the West Coast of America by Prof. F. H. Bradley, it seems useful to notice here some of the more interesting and new species. These will hereafter be more fully described and figured in the Transactions of the Connecticut Academy. Most of the following species were obtained by pearl divers near La Paz.

Semele Junonia Verrill, sp. nov.

A large, broad, somewhat oval species; anteriorly much prolonged and broadly rounded; posteriorly shortened, strongly plicated, the extremity broadly obliquely truncate. Surface covered with regular, nearly equidistant, elevated, strong, concentric lamellæ, which are not close, except near the umboes, but beyond the plication become fainter, oblique, and parallel with the truncated posterior edge; interstices broadly concave, smooth, with fine radiating grooves in the larger specimens, and also sometimes with concentric striæ. Epidermis thin, shining, yellowish brown. Beaks but little prominent; dorsal edge of the right valve overlapping the ligament and even more overlapping the edge of the left valve in front of the beaks. Hinge stout and broad, its inner edge very sinuous;

the internal ligament strongly divergent from the margin, its plate obliquely concavely truncate posteriorly; lateral teeth stout, obtuse. Palial sinus large, broadly rounded, reaching about the middle, its surface finely striated and iridescent. The color of the interior is usually a rich pink or deep flesh-color, lighter about the hinge; sometimes yellowish or bright orange; externally generally orange-yellow, with the umboes bright orange-yellow. One large specimen is pale yellow, with bright lemon yellow umboes; the inside yellowish white with the palial sinus and broad concentric bands pinkish.

Length,	3·15	inches.	2·55	2·35	1·44
Height,	2·65	"	2·20	2·05	1·16
Breadth,	1·40	"	1·12	·90	·52
Apex to anterior end,	2·10	"	1·86	1·60	1·00
Plication to posterior end,	·80	"	·60	·50	·32
Palial sinus from edge,	1·85	"	1·50	1·38	·85
Breadth of do.,	·87	"	·74	·62	·32

Near La Paz,—Capt. J. Pedersen. Six fresh specimens, the valves mostly together. Obtained by pearl divers.

This fine species is allied to *S. rosea* and *S. Jovis.* The latter, as figured by Reeve (Icon., vol. viii, Pl. v, 34), is similar in form and somewhat in color, but the lamellæ are closer, and the plication is nearer the posterior edge. The hinge and palial sinus are not described, and the locality is unknown.

S. rosea (Sowerby, 1832) was described from a single valve found at Tumbez, Peru. It is more orbicular and the lamellæ are much closer.

Semele formosa.

Amphidesma formosum Sowerby, Proc. of the Committee of Science and Correspondence of the Zoöl. Soc. of London, Part II, 1832, p. 199; Reeve, Icon., viii, Pl. iv, fig. 27.

Semele formosa Adams, Genera, ii, p. 411.

Of this lovely species two fresh specimens with the valves together and two fresh odd valves were obtained with the preceding.

The form is much like that of *S. Junonia,* but the anterior dorsal edge is not concave, does not overlap, and the beaks are, therefore, even less prominent. The sides are covered with close, more or less irregular, often slightly oblique, concentric, rounded ribs, which are often furcate, especially at the posterior fold, separated by intervals of about their own width, and become very fine and close toward the apex, and often interrupted and nodulose on the umboes and anteriorly; beyond the strong posterior plication they are stouter, irregularly bent up and crowded, toward the apex rugose. Hinge less stout than in the preceding, the internal ligament more parallel and nearer to the margin, its plate not truncately terminated. Palial sinus large, broadly rounded, iridescently striated.

The color is varied with white, light lemon-yellow, rosy, brown, and purple; these colors being arranged partly in numerous rays, partly in spots and patches. Usually there are many alternating narrow rays of white and rosy, the other colors being more irregularly distributed, but in one specimen there are also regular rays of yellow on one valve. Inside the larger specimens are pinkish white, the middle and umbonal regions bright yellow, the ligament plate deep purple; but smaller specimens are mottled with purplish red and yellow.

The largest specimen is 2·75 inches long; 2·25 high; 1·05 broad; the palial sinus 1·62 long, from edge; ·85 wide.

Semele venusta (A. Adams, 1853) is perhaps only the young of this species. It was from West Columbia.

Callista pollicaris.

Carpenter, Ann. and Mag. Nat. Hist., vol. xiii, p. 312, 1865.
Dione prora var., Reeve, Conch. Icon., xiv, Pl. x, fig. 45, (*non* Conrad).

Several specimens of this rare and beautiful species were obtained, which show considerable variation, especially in color. Most of these are more transversely oval and less rounded below than the specimen figured by Reeve. The posterior end is always a little compressed and somewhat obliquely truncate. Ligamentary area long and narrow, slightly excavate, wrinkled. The sides are smooth and polished, finely concentrically striated; posteriorly and anteriorly obliquely corrugately wrinkled in most of the specimens, but in some, especially the smaller ones, the anterior wrinkles are obsolete, and sometimes also the posterior ones. Palial sinus large, broad and oval. Some specimens are white, with only a few small specks or waved lines of orange-brown, and a few stripes of the same color on the ligamentary area, the apex orange, upper part of lunule brown; more commonly the color is yellowish with concentric waved or zigzag streaks and spots of orange-brown, sometimes with imperfect radiating bands of the same color in addition; a large specimen is thus marked for about an inch from apex, beyond which it is white, faintly specked with brown. One large specimen is nearly white with many radiating bands of orange-brown on one valve; on the other diffused orange-brown, lighter above, crossed by many radiating darker brown bands. Another is darker chestnut-brown below, yellowish white toward the umboes, but destitute of bands and spots. Some of the smaller specimens have a purplish brown stain within, crossing the palial sinus; others are pure white.

Length,	2·10	inches.	2·08	1·75	·88
Height,	1·50	"	1·45	1·25	·66
Breadth,	1·00	"	1·00	·80	·44
Apex to posterior end,	1·75	"	1·68	1·35	·68
Palial sinus from edge,	1·15	"	1·10	95	·46

Near La Paz,—Capt. J. Pedersen.

This species belongs to the subgenus, *Caryatis*, of Römer.

Tivela elegans, sp. nov.

The form is regular, transversely subelliptical, triangular above, nearly equilateral, slightly swollen at the umboes; the beaks but little prominent. Ligament short; lunule elongated, distinctly defined. Hinge narrow, not very strong. In the left valve the anterior tooth is prominent, about its own breadth from the beak; four principal cardinal teeth, nearly equally divergent, rather thin, the posterior one bilobed, the marginal lobe prolonged; in the right valve four principal, thin cardinal teeth, the middle ones most prominent, rugose, palial sinus large, broadly rounded, reaching nearly to the middle.

The La Paz specimens show great variation in color. Some are white with a few posterior oblique lines or spots of reddish brown; others are broadly indistinctly rayed and posteriorly wave-striped with lighter and darker grayish brown, leaving the umboes and two narrow radiating bands yellowish white. One is intricately and beautifully painted with rich reddish brown, in regular, concentric, waved and angulated bands, becoming zigzag posteriorly, with several median interrupted white rays, which differ on the two valves, and the posterior edge stained deep brown; this is deep purple within, except apical and anterior and posterior whitish spots. The lighter specimens are white within, except a spot of purplish about each muscular scar.

The San Salvador specimens present many other variations in color, but are mostly white, more or less profusely painted with chestnut-brown in various concentric, more or less waved and angulated bands, or in interrupted rays; in some the color is yellowish brown; in others the ground-color is reddish brown, with darker bands. The beaks are sometimes, but not usually, purplish; the interior generally white, with a purplish umbonal stain.

	T. elegans.					*T. Hindsii.*
Length,	1·02 inches.	·98	·82	·74		·65
Height,	·78 "	·80	·65	·58		·62
Breadth,	·48 "	·50	·42	·40		·50

La Paz,—Capt. J. Pedersen; Acajutla and Realejo,—F. H. Bradley.

This species varies somewhat in form, but is nearly always more traversely oval than *T. Hindsii*, of which we have typical specimens both from San Salvador and Zorritos, Peru, which agree exactly in form and color with Reeve's figures. *T. Hindsii* is short, triangular, with very swollen umboes, and the posterior end longest and a little produced, its sinus much smaller, and the ligament very short, the hinge stouter, with the lateral teeth nearer the cardinal, and the latter more crowded and stouter. *T. radiata* is less regular in form than *T. elegans*, with much smaller sinus and broader and stouter hinge, a much longer ligament, sharper lateral tooth, and more numerous and more divergent cardinal teeth, the posterior ones being much more elongated.

The name, *Trigona* (Meg., 1811), is not only *later* than *Tivela* (Link, 1807), but was previously used among Hyemenoptera (Jur. 1807). It has also been used in Crustacea (Latr., 1817).

Venus isocardia, sp. nov.

A large, rounded, thick, and swollen species, cordate in front, with a broad deeply excavated lunule; with the sculpture entirely concentric,—the stout, elevated, rather close, slightly recurved and flattened ribs separated by deep interstices in which there are several very thin, crowded, slightly elevated lamellæ. Umboes prominent, swollen, the beaks much recurved, not marginal; dorsal outline convex, broadly rounded and a little produced posteriorly; evenly rounded ventrally; anterior end short, deeply indented by the very broad and sunken lunule, which is smoothish and surrounded by a distinct groove, broadly cordate, extending between the beaks. Ligamentary area narrow, smooth on the left valve, the concentric sculpture extending over it on the right valve, which overlaps beyond the ligament. Muscular scars and palial line strongly marked, the sinus of moderate length, tapering to an obtuse point, about as deep as the width of the posterior muscular scar. Hinge stout, the anterior tooth in the right valve elevated and stout; central much larger, slightly bilobed; posterior one much elongated, and strong. In the left valve there is a small, conical, tubercular, anterior tooth; first cardinal elevated, stout triangular; followed by a stout strongly bilobed one; posterior one confluent with the ligament plate, long and curved, less elevated.

Exteriorly more or less stained and blotched with brownish; interiorly tinged with light orange near the umboes.

Length 3·25 inches; height 3·30; breadth 2·50; breadth of lunule ·68; length of palial sinus ·60.

Near La Paz,—Capt. J. Pedersen. Two fresh specimens.

This massive species is allied to *V. rugosa* of the West Indies, which it resembles in form and sculpture, but it has a different and stronger hinge. The posterior tooth of the right valve, especially, is much larger and longer, extending beyond the middle of the ligament. In the left valve the posterior tooth is also much elongated and reaches beyond the middle of the ligament, but it is much less elevated than in *V. rugosa*, and less separated from the ligament plate, there being only a shallow groove between.

It belongs to the typical *Venus*, as restricted by Messrs. H. and A. Adams and most recent authors, but Römer has given the subgeneric name, *Ventricola*, to this group.

Chione tumens, sp. nov.

A stout, thick, often swollen, subtriangular, somewhat beaked species, with broad, swollen, rounded, concentric ridges or undulations, increasing in size from the beaks to the margin, with faint radiating sculpture on the upper side of the ridges. The dorsal outline is nearly straight, the ligament groove broad and deeply excavated, smoothish in both valves, with a short ligament; posteriorly slightly truncate; ventrally broadly rounded; anteriorly rounded and a little produced; the lunule broad-oval, deeply sunken, smoothish, or marked with slight radiating lines. Beaks a little recurved, marginal. The concentric ridges or swellings are 12 or 14 in number, those near the beaks quite small and close, but rapidly becoming broader and more elevated; so that the last three occupy an inch or more in breadth; their upper surface is somewhat flattened and marked by low, crowded, radiating ridges, which are obsolete, or nearly so, on their outer side. The hinge is stout, its inner edge sinuous; the small anterior tooth in the right valve is thin and but slightly elevated; the central one stout, triangular and elevated; in the left valve the anterior tooth is stout, somewhat triangular and acute, as much elevated as the central tooth, but not so stout. Palial sinus quite small. Color externally, whitish, yellowish, or light brownish, variously marked and blotched with dark brown, which is sometimes in large radiating bands or spots, intermixed with narrow angular lines; at other times the brown markings are so numerous and crowded as to nearly conceal the ground color; within whitish, or with a dark purple stain posteriorly.

Length,	1·60	inches.	1·48	inches.
Height,	1·55	"	1·35	"
Breadth,	1·20	"	1·10	"
Apex to posterior end,	1·45	"	1·25	"

La Paz,—Capt. J. Pedersen. Forty-two specimens, mostly odd valves.

This species is very distinct from all others in its form and peculiar broad swollen ridges. It slightly resembles *C. subimbricata*, especially in color, but in the latter the first ridges are lamellar and the later ones much smaller, more numerous, and less swollen, while the shell is less beaked, the umboes less swollen, and the anterior edge is much less recurved and shorter, but the posterior more pointed. The hinge in *C. tumens* is also much broader and stouter, with the inner edge much more sinuous and the teeth longer and stouter.

Chione succincta.

Venus succincta Val , in Humb. Rec. d'Orbs., vol. ii, Pl. 48, fig. 1, p. 219, 1833, (t. P. P. Carpenter).

V. leucodon Sowerby, Proc. Zoöl. Soc. Lond., p. 43, 1835.

V. Californiensis Broderip, op. cit., p. 43; Reeve, Icon., Pl. xi, fig. 35, (*non V. Californiana* Con.).

V. Nuttallii Conrad, Jour. Acad. Nat. Sci Phil., vii, p. 250, Pl. 19, fig. 16, 1837; Reeve, Icon., Pl. xiii, fig. 49, 1863.

Chione succincta Carpenter, Rep. Brit. Assoc., 1863, pp. 569 and 620.

A fine series of this species is contained in the collection, including about fifty fresh specimens with valves together, and over a hundred odd valves of all sizes. These show considerable variation and confirm the synonymy of Dr. Carpenter, as given above.

In this species the shell, when adult, is thick and heavy, generally white, or nearly so, externally and internally, except that there is usually a deep purple stain posteriorly within, and often two spots or short triangular radiating bands near the apex, which is often purple or brown at tip. The form is somewhat triangular ovate, with the umboes and beaks quite prominent and recurved. The lunule is sometimes brown, generally narrow and ribbed; the ligamentary area is excavate, smooth on the right valve, and often nearly so on the left, though more commonly the concentric ribs extend around upon it in the form of crowded, more or less prominent wrinkles or slight folds; it is generally tinged with light brown or purple, on the right valve sometimes striped transversely with deep brown.

The sculpture is quite variable in the prominence and distance between both the radiating and concentric ribs, especially the latter. Over the umboes the radiating ribs are strong, and either alternate with smaller ones, are arranged by twos or threes, or are nearly uniform for some distance; posteriorly they become obsolete or nearly so, and in large specimens they gradually fade out and disappear at 2 to 2·5 inches from the apex, where the concentric ribs generally begin to become stronger, crowded, and more recurved. The concentric ribs on the umbonal region are generally ·10 to ·15 of an inch distant, toward the apex closer, and toward the base closely crowded, though not always so. The hinge is very strong, the teeth large, and the palial sinus very small.

Some of the larger specimens give the following measurements:

Length,	2·85	inches	2·65	2·75	2·60
Height,	2·85	"	2·70	2·75	2·55
Breadth,	1·65	"	1·60	1·70	1·60

La Paz,—J. Pedersen. It appears to live buried in sand or mud with only the posterior end exposed, which is therefore more or less worn and discolored in large specimens.

Chione undatella.

Venus undatella Sowerby, Proc. Zoöl. Soc. Lond., iii, p. 22, 1835; Reeve, Icon., xiv, Pl. 16, fig. 68.
V. neglecta Gray, Voyage Blossom, p. 151, Pl. 41, fig. 8, 1839, (t. P. P. C.).
V. simillima Sowerby, Thes. Conch., xvi, p. 708; Reeve, Icon., fig. 44.
V. perdix Val., Voyage, sur la frégate la Vénus, Pl. 16, fig. 2, 1846.
V. subrostrata Reeve, Icon., xiv, fig. 54, 1863, (*non* Lam.).
(?) *V. bilineata* (*pars*) Reeve, Icon., Pl. 22, fig. 105 a.
Chione undatella Desh., Catal. Venerid of Brit. Mus., p. 141.

A large series of this variable species was obtained, which shows that several nominal species have been based on characters that have no constancy. In its most normal condition it is more swollen, less triangular above, with the anterior end less produced, and the beaks much less prominent than the preceding. The sculpture, though variable, is similar, but generally the concentric ribs are closer and more regular. The lunule and ligamentary area are similar, but the latter is perhaps generally rougher on the right valve or both. The hinge is scarcely different, though somewhat variable with age, but the posterior tooth is perhaps generally somewhat longer, and the inner edge of the hinge-plate a little more sinuous. The palial sinus, as in the preceding, is very small. The color is quite variable. It is rarely perfectly white; more commonly externally buff or light cream-yellow, with transverse, waved or zigzag irregular stripes and radiating, often interrupted bands and irregular patches and spots of brown, sometimes also of purplish. Sometimes the brown markings are very light and scarcely distinct, the general color being buff; sometimes the markings are all regularly deeply angulated or zigzag lines, except on the umboes, which are blotched with brown; the apex is often bright brown or purplish; the broad radiating bands are frequently three or four in number and very distinct; many are merely mottled and spotted. Internally there is generally at least a more or less extended posterior purple stain; frequently the whole interior is tinged with a rich reddish purple, deepest outside of the palial line, with the hinge teeth bright red or lilac; sometimes the interior is pure white. The lunule and ligamentary area are usually stained or spotted with brown, the latter often with regular transverse stripes on the left valve.

In the *var. simillima* the radiating ribs are much finer posteriorly, fimbriating the concentric lamellæ, but there is also some appearance of this in the typical form, and some specimens have this form of sculpture for an inch from the apex, beyond which it fades out and the lamellæ are smoothish, or but slightly wrinkled.

Length,	2·05	inches.	1·95	1·90	1·80
Height,	1·95	"	1·85	1·55	1·65
Breadth,	1·30	"	1·30	1·05	1·10

La Paz,—J. Pedersen. With the preceding.

This species is very closely allied to *C. succincta*, and although the ordinary adult specimens are quite different in form and color, there are specimens which are, to a considerable extent, intermediate. It is also nearly impossible to satisfactorily separate young specimens, half an inch in diameter or smaller.

Papyridea bullata Sw. *var. Californica*, nov.

In form and color like the ordinary West Indian specimens, but perhaps a little more elongated than the average Atlantic form. Sculpture also similar in all respects, except that the radiating ribs are more prominent in the middle and especially over the umboes. The hinge shows some differences. In both valves the anterior lateral tooth is less prominent, narrower, and smaller, and the ligament plate is more prolonged and not so squarely truncate, reaching to or beyond the center of the posterior lateral tooth. The color externally is generally yellowish-white variously mottled and spotted with purplish brown; internally white, more or less stained with purple; one specimen is mottled with orange externally, and stained within with the same color, like some of the West Indian. The largest specimen is 1·75 inches long and 1·38 high.

La Paz,—J. Pedersen. Ten specimens.

Cardita Cuvieri.

Broderip, Zoöl. Soc., Proc. of Comm. of Science, p. 55, 1832.
Cardita Michelini Val., Voy. Vénus, Pl. 22, fig. 5, 1846.
Actinobolus Cuvieri Adams, Genera Rec. Moll., ii, p. 487, 1858.

Four large specimens of this rare and interesting species were obtained. They vary but little in form, color, or sculpture. In all the beaks are strongly recurved, umboes very prominent, the posterior depression strongly marked, the ribs very stout, flattened, transversely nodose, with deep square-cut grooves between. The color is deep mahogany brown, varying in shade; within white.

Length,	2·50	inches.	2·10	2·15
Height,	2·45	"	2·20	2·15
Breadth,	2·25	"	1·80	1·65

La Paz,—J. Pedersen. From pearl divers.

Cardita crassa.

Gray, Voyage of the Blossom, p. 152, Pl. 42, fig. 4, 1839, (t. P. P. Carpenter).
Actinobolus crassus Adams, loc. cit., p. 487.

This species appears to be more common than the last. It is more pointed, with the beaks less recurved; the posterior depression less marked; the ribs fewer, less prominent, low and rounded, with the interspaces, broad, shallow, concave, concentrically wrinkled. Color deep reddish brown; sometimes with triangular lateral, or posterior transverse spots of yellow, the beaks white.

Length,	1·90	inches.	1·95	·65
Height,	2·20	"	2·10	·67
Breadth,	1·05	"	1·50	·50

La Paz, with last,—J. Pedersen.

Loripes edentuloides, sp. nov.

Closely allied to *L. edentula* of the West Indies and Gulf of Mexico.

It is subglobose, and much more swollen than *L. edentula*. The apex is more prominent and curved, and the lunular region more deeply excavated. The ligament is shorter and its supporting plate is not so stout, and its inner edge but little elevated above the ligament groove.

Length 1·65; height 1·50; breadth 1·10.

La Paz,—J. Pedersen. One specimen.

This is of special interest as another Gulf of California shell closely allied to a characteristic West Indian species. A large series of specimens might, perhaps, connect the two forms, but at present it seems necessary to keep them separate.

Xenophora robusta, sp. nov.

Shell large, elevated, regularly conical. Whorls seven or more, overlapping, bearing large pebbles and fragments of shells and corals intermingled, exposed surfaces roughly corrugately wrinkled, much crowded. Base broad, concave, densely and finely corrugated, spirally rudely costate by the lines of growth; yellowish brown. Aperture large, the inner lip and columella with a thick, lustrous, deep brown callus, which extends into the shell. Umbilicus closed by the reflexed inner lip.

Height,	2·35	inches.	1·70
Breadth,	2·75	"	2·20
Length of last whorl,	·85	"	·80

Near La Paz,—J. Pedersen. Two fresh specimens.

One of the specimens bears some large fragments of a shell that appears to be *Chione undatella*, the sculpture and color being preserved.

This genus appears to have been previously unknown on the west coast.

Enæta Pedersenii, sp. nov.

Shell small, rather slender, elongated; the spine regularly conical, acute, about two thirds the length of the body whorl; each whorl much flattened below the suture and encircled by a row of rounded tubercles; the body whorl with low, rounded, longitudinal costæ below the tubercles. Whole surface finely longitudinally sulcated or striated, on the upper whorls also transversely striated. Aperture narrow, contracted above, the outer lip much thickened, the edge subreflexed, bearing at about the upper third a stout tubercle, below which it is crenulately toothed within; contracted at base by another small tubercle. One specimen, probably immature, lacks the tubercles and crenulations; columella with about seven plaits, the four lowest largest. Siphon narrow, a little prolonged and recurved, with acute edges. Color fulvous brown, specked with bluish white, with an interrupted band, or spots, of deep brown below the suture, a pale band over the tubercles and another, bordered with brown, below the middle of the body whorl. Length 1 inch; breadth ·50; length of body whorl ·63; length of aperture ·68; breadth ·12.

La Paz,—J. Pedersen. Five specimens.

This species is closely allied to the next, but is more slender, with the spire more acute, smaller tubercles and costæ, a more prolonged and recurved siphon, and more contracted aperture. The surface is not smooth and the color is lighter.

Lyria (*Enæta*) *Cumingii.*

Voluta Cumingii Brod., Zoöl. Soc. Proc. of Comm. of Science, 1832, p. 33.
Lyria (*Enæta*) *Cumingii* Adams, Genera, p. 167, 1858.

Our specimens are rather stout and solid, with large swollen tubercles and costæ, and a smooth polished surface. The best specimen lacks the tubercle on the inside of the outer lip, which is somewhat flaring and much thickened. The siphonal notch is scarcely prolonged and not recurved. The color is dark and rich brown, mottled and spotted with light bluish and flesh-color, with submedian and tubercular interrupted paler bands on the last whorl and an interrupted band of deep brown spots below the suture on the spine; interior salmon-color.

Length 1·33; breadth ·75; length of body-whorl ·85; aperture ·23 broad; ·82 of an inch long.

La Paz,—J. Pedersen. Three specimens.

Among the other species of special interest are *Codakia tigerina* (large and abundant), *Lucina undata* Carpenter, *L. excavata* Carp., in several varie ies, *Mactrella exoleta*, *Tellina Cumingii* (abundant and fine), *Raeta undulata* (numerous valves), *Cyathodonta plicata*, *Placunanomia Cumingii* (three large specimens), *Conella cedonuelli* (many varieties of color), *Conus* (like *textilis*), *Cypræa pulchra* Kiener (ten specimens), *Cypræa* (*Luponia*) *Sowerbyi* and *L. albuginosa* (both in considerable numbers), *Cassis tenuis* (finely colored), *Harpa crenata* (several varieties of color), *Cassidulus patulus*, etc., all from La Paz and vicinity.

Note to Contributions to Zoology, No. V.—In the last number of this Journal, page 99, the generic name, *Oreaster*, should be substituted for *Pentaceros.* This change was made in the proof, after obtaining the reference to *Pentaceros* in Cuv. and Val., but the correction was overlooked by the printer.

ART. XXVII.—*Notice of Dr. Gould's Report on the Trans-Atlantic Longitude.**

DR. GOULD'S able Report on the trans-Atlantic longitude has at last been published. It is full three years, however, since the field work to which it relates was finished, and more than two, as we learn from a prefatory note, since the paper in its present form (except the last chapter) was ready for the press. Astronomers have waited for it until patience was well nigh exhausted. Yet, thankful now that it is at last within reach, they will scarcely trouble themselves to press the question, why, or by whom, it has been so long withheld, or why it is now published by the Smithsonian Institution, and not by the Coast Survey itself, under whose auspices the work was done. For ourselves, waiving these, and like queries, as probably admitting of satisfactory answers, or, at least, such as would free the author of the Report from responsibility for the unexplained delay, we turn rather to the more welcome task of examining the Report itself, and laying some of its points before the readers of this Journal.

The paper fills a hundred quarto pages of the Smithsonian Contributions, and is one of the most important yet published on telegraphic longitude. For not only was the undertaking to which it relates among the most difficult and delicate, as well as important, of its kind, but the party put upon it brought to their task nearly the sum total of all the experience and practical skill that had then been developed in this special field; their chief having for fifteen years had exclusive charge of the longitude operations of the United States Coast Survey, and his associates, likewise, a long training in the same service. The Report may be taken, therefore, as a good exemplification of the telegraphic method in one of its latest and most difficult applications, and at the same time, as but a sample of the vast store of similar material that has been accumulating under the same hand from the entire longitude work of the Survey—material which embraced, before the war, no less than twenty-four independent determinations in the Atlantic and Gulf States—and which, surely, ought not to be much longer lost to science.

The Telegraphic method, it is now well understood, is distinctively American, and has had its chief development in the work of our great national Survey. That Survey has, in fact, among its many important contributions to science, given to the world

* The Trans-Atlantic Longitude, as determined by the Coast Survey Expedition of 1866. A Report to the Superintendent of the U. S. Coast Survey. By Benjamin Apthorp Gould, late assistant. Washington City: published by the Smithsonian Institution, 1869. New York: D. Appleton & Co.

the best methods yet devised of determining both latitude and longitude—Talcott's for the one, and the Telegraphic for the other; the former, devised in 1834, giving us in a single night's work with the zenith telescope, or a transit instrument used as such, the latitude to a small fraction of a second, and the latter, the longitude, also, for the first time in the history of geodesy, with corresponding facility and precision—a facility and precision, taken together, wholly unattainable by other methods, and in the case of longitude especially, unapproachable even, particularly in extended operations.

It was not till some years after the telegraphic method had been well elaborated here, and in successful use, that it received much attention abroad; and even then, the modes of practice recommended as original, by even eminent astronomers, particularly in France, were only such as had been long employed in our Coast Survey, or superseded by better, and had been published to the world repeatedly, and through various channels.

Almost simultaneously with the invention of the telegraph must have occurred to astronomers the idea of using it in determining longitudes. It was natural enough, therefore, that Arago should, in 1837, as is said, have suggested such a use of it to Morse. But the first actual experiment, so far as we know, was made, on the Baltimore and Washington line, in 1844, by comparison of chronometers at the two termini. The experiment was conducted by Captain Wilkes.

The method had, before this, engaged the attention of Prof. Bache, and he, quick to discern its advantages, in November, 1845, ordered its use in the longitude work of the Coast Survey—then in charge of the eminent astronomer, S. C. Walker; who, the next year, made a successful trial of it on the line between Philadelphia and Washington. From 1848, on, it was the method employed systematically in all determinations between points in the United States. Mr. Walker tried both the method of clock-signals, used in the experiment between Baltimore and Washington, and also the superior one of star-signals, used in the Coast Survey practice, almost exclusively, from the first. Dr. Gould succeeded Mr. Walker in 1851; and in the widely extended operations of the next ten years, brought the method to a very high degree of efficiency, and, with his aids, acquired that thorough mastery of the subject, which so well fitted both him and them for the difficult task, the history and results of which are set before us in this Report.

Dr. Gould's paper contains twelve chapters: 1, Origin of the Coast Survey Expedition; 2, Previous determinations of the trans-Atlantic longitude; 3, History of the Expedition; 4, Observations at Valencia; 5, Observations at Newfoundland; 6, Observations at Calais; 7, Longitude-signals between Foilhommerum and Heart's Content; 8, Longitude-signals between Heart's Content and Calais; 9, Personal error in noting signals; 10, Personal equation in determining time; 11, Final result for longitude; 12, Transmission-time of the signals.

The expedition had for its object a more exact determination of American longitudes, as reckoned from a European zero, than had yet been made. It was important, for the purposes of the Coast Survey, and of astronomical science, that the trans-Atlantic longitude should correspond in precision with those determined telegraphically within our own borders. The previous determinations of that longitude whether by moon-culminations, by eclipses and occultations, or by chronometers, differed very widely from each other. The range of difference was no less than five or six seconds in time. We take for comparison, the longitude from Greenwich, of the Naval observatory at Washington. This depends mainly on that of Cambridge, and this again, in part, on that of New York, Philadelphia, and other places. Between these points the longitude has been measured telegraphically. That between Washington and Cambridge was found by Walker, in 1848–9, to be $23^{m}\ 41^{s}\ 54$, and has never been re-determined; but the link between New York and Jersey City was determined only geodetically, and that between Jersey City and Washington by simple clock-comparisons instead of the better method of star-signals; while another geodetic link was that of $12^{s}{\cdot}44$, between the Naval observatory and the Seaton station in Washington, to which all the telegraphic longitudes of the Coast Survey are referred. On account of these circumstances, and the omission, besides, in these earlier determinations, of many of the refinements and precautions since introduced, it seems highly desirable, as Dr. Gould suggests, that the longitude between New York and Washington, which he regards as the only weak link in our whole chain of telegraphic longitudes, should be carefully re-determined. Walker's value, however, as here given, is presumed to be very near the truth. Using the above quantities, Dr. Gould finds for the determinations of the longitude of the Naval observatory from Greenwich, which have appeared best entitled to confidence in recent years, the following:—

1. *From Eclipses and Occultations.*—The value adopted in the volume of Observations for 1845 is $5^{h}\ 8^{m}\ 14^{s}{\cdot}64$. Peirce, in 1845, from occultations observed by Bond from 1839 to 1841, gave $5^{h}\ 8^{m}\ 13^{s}{\cdot}9$. Walker, from all available observations between 1767 and 1842, obtained $5^{h}\ 8^{m}\ 14^{s}{\cdot}16$, a value subsequently reduced to $13^{s}{\cdot}85$, by change in the adopted longitude of Philadelphia, Cambridge, and Washington. A correction of the lunar parallax, deduced by Airy, Walker and others, from various observations, required a still further diminution of all

American longitudes; so that we have at present from eclipses and occultations:

Walker, corrected value from observations before 1843,	$5^h\ 8^m,\ 11^s{\cdot}14$
Peirce, from eclipse of 1851, July 28,	11·57
Peirce, from emersions of Pleiades, 1839, Sept. 26,	11·45
Peirce, " " " 1856–1861,	13·13

2. *From Moon Culminations:—*

					h. m. s.
Walker,	from	Cambridge	obs'tions,	1843–45	5 8 10·01
Loomis,	"	Hudson	"	1838–44	9·3
Gilliss,	"	Capitol Hill	"	1838–42	10·04
Walker,	"	Washington	"	1845	9·60
Newcomb,	"	"	"	1846–60	11·6 ±0·4
Newcomb,	"	"	"	1862–3	9·8

Walker considered $9^s{\cdot}96$ as the most probable value from moon-culminations, and Newcomb assigned $11^s{\cdot}1$ as that indicated by the Washington observations from 1846 to 1863, inclusive.

3. *From chronometers transported between Boston and Liverpool.*

	h. m. s.
Mean from 373 previous to 1849,	5 8 12·46
Bond's discussion of 175, expedition of 1849,	11·14
Walker's " " " "	12·00
Bond's " " " "	12·20±1·20
Bond's " of 52, 6 trips, expedition of 1855,	13·43±0·19

The new telegraphic determination of the longitude between Liverpool and Greenwich adds $0^s{\cdot}06$ to all these values.

The discordance of the most elaborate and trustworthy results obtained by the old methods is thus seen to exceed four seconds. The value employed by the Coast Survey from 1852 to 1859 was $5^h\ 8^m\ 11^s{\cdot}2$; since 1859 it has been $5^h\ 8^m\ 11^s{\cdot}8$.

This great uncertainty of the trans-Atlantic longitude—from 30 to 60 times greater than that of our Coast Survey determinations—required that the earliest opportunity presented by the successful laying of an ocean cable should be seized for determining this longitude telegraphically, and with all possible precision. Measures were early taken to use, for this purpose, the cable of 1858, and, again, that of 1865; but, of course, in vain. In 1866, however, the cable of that year, and the recovered cable of the year before, afforded the desired opportunity. The expedition, organized under authority of the Coast Survey, was directed by Dr. Gould, and composed of officers of the survey, who were among the most skilled in longitude work. Messrs. Gould and Mosman went to Valencia, Ireland, Messrs. Dean and Goodfellow to Heart's Content, Newfoundland, and Messrs. Davidson and Chandler to Calais, Maine; for, the complete solution of the problem in hand, required the determination of three separate longitudes: 1, between Greenwich and Valencia; 2, between Valencia and Heart's Content, and 3, between Heart's Content and Calais, the easternmost station of the series connected by the telegraphic determinations of the Coast Survey. The first was accomplished by the ready co-operation of the Astronomer Royal. The second and third involved the principal labor, and presented the chief difficulties.

And these difficulties were by no means trifling. Wretched climate, defective land lines, unprecedented distance, with other untoward conditions, all conspired to render success by no means easy. Neither Valencia, nor Newfoundland, had, it would seem, any attractions for an astronomer. At Valencia, the observers were informed, on their arrival, early in October, that it had rained every day, without exception, for eight weeks. It was not until the 14th that any instrumental adjustments whatever, could be effected. During the seven weeks of their sojourn "there were but four days on which no rain fell, and there was but one really clear night during the period while the instruments were in position. The observations were, in general, made during the intervals of showers; and it was an event of frequent occurrence for the observers to be disturbed by a copious fall of rain while actually engaged in noting the transit of a star." The climate of Newfoundland appears to have been no better for astronomical work than that of Valencia. Messrs. Dean and Goodfellow reached Heart's Content on the 20th September, but saw neither sun, moon, nor stars until the 16th October, when they made their first imperfect adjustments of the transit and clock. In such circumstances, it is certainly most creditable to the skill and energy of the observers, that so many and excellent observations were obtained, as are discussed in this report.

The most formidable difficulty encountered, however, was the defective condition of the long land line of 1,100 miles between Newfoundland and Maine. On this line there were no less than four "repeaters," or double relay magnets, and two stations at which messages were re-written, without even an automatic "repeater," until these indispensable instruments were furnished for those stations by Mr. Davidson. But even with these provided, and with the most laborious precautions taken in other respects, all efforts at direct communication proved unavailing, day after day, and week after week. Mr. Davidson's health becoming impaired, his place at Calais was taken by Mr. Boutelle, one of the most experienced officers of the survey. Singularly enough, it was only a couple of hours before his arrival, on the 11th December, that, suddenly, the long-desired communication was found to be established. "A sharp frost had thrown the otherwise defective line into a condition of admirable insulation, so that an interchange of clock signals was effected without difficulty." The signals afterward obtained over this line were, in the main, quite satisfactory, and sufficiently numerous to ensure a trustworthy result; still this third link in the chain of longitudes is undoubtedly its weakest part.

A further difficulty was presented by the unprecedented interval between the meridians; necessitating the use of simple clock-comparisons instead of star-signals, and preventing the interchange of observers for eliminating the effects of personal equation. Star-signals—i. e., signals transmitted at the instant a given star passes the several wires of the transit instrument, first at one station and then at the other, and registered at both—have these advantages over mere clock-signals—beats sent from each station and similarly registered—that they give results independent of the star's right ascension, which, cannot be said of the other; that, unlike the other, they are independent also of absolute time-determinations, though not of instrumental errors; and, finally, that they yield results affected only by the clock's rate, and not its error, in the interval of the star's passage between the two meridians. Where this interval is large, as in the case before us, the special advantage of star-signals mainly disappears; and even if it did not, they would require too protracted an occupation of the cable, and in the climate encountered, or indeed, in any climate, the chances would be great, with an interval of three hours, against the same star being observed at both stations.

With the superior catalogue of time-stars, however, which had been prepared, and with the careful experiments for personal equation which were made both before and after the expedition, there was good reason to believe that, even with the clock-method, necessarily used, no sensible, or at least, considerable error depending on the right ascensions would be introduced, nor any, also, arising from uneliminated personal equation. That this was true, in both cases, the discussion of these points in the report seems conclusively to show.

Still another serious obstacle in the way of accurate longitude determination was the absence of any means for the automatic registration of the signals received; inasmuch as the loss of time in noting the signals was, in the method employed, not only considerable, but quite uncertain. The most sensitive electro-magnet tried, could not be actuated unless by a charge of the cable too strong to allow the transmission of signals with sufficient rapidity. When the Valencia clock was breaking circuit during an eighth part of every second, a permanent deflection only was observed at Newfoundland.

The instrument actually employed for receiving signals was Sir W. Thomson's very ingenious reflecting galvanometer, the construction and performance of which are thus described. "A small mirror, to the back of which is attached a permanent magnet, the joint weight of the two being from five to six centigrams, is held, by means of a single fiber above and below, in the center of a coil of fine wire, which forms part of the galvanic circuit; and its position and sensitiveness are regulated by movable bar-magnets placed in the immediate vicinity. Upon the mirror is thrown a beam of light through a slit in front of a bright kerosene lamp, and the deflections of the needle are noted by the movements of the reflected beam, which is received upon a strip of white paper. The exquisite delicacy of this galvanometer, as well as the electrical excellence of the telegraph cables, may readily be appreciated after the beautiful experiment in which the electricians at Valencia and Newfoundland conversed with each other on a circuit not far from 700 myriameters (4,320 statute miles) in length, formed of the two cables joined at the ends, using a battery composed of a percussion gun-cap, a morsel of zinc, and a drop of acidulated water."

It is obvious that, with this instrument, there must be an appreciable loss of time in noting signals, due to inertia of needle, etc., which would be avoided, or more definitely measurable, with an automatic register. But no such register was available. Fortunately, this loss, as is shown in the chapter on "Personal error in noting signals," proved to be more constant and measurable than was anticipated, and, affects the final result only in a very slight and limited degree. A very delicate automatic receiving apparatus has since been suggested by Dr. Gould for recording the signal on the chronograph, by contact of the galvanometer needle, whenever slightly deflected, with wires placed close on each side of it, and properly connected with the battery.

The other instruments used were the regular apparatus of the telegraphic party of the Coast Survey; at each station, a 46-inch transit instrument, with reversing apparatus, and a reticule of five "tallies," of five spider lines each; a chronograph, (Bond's "spring governor," at Valencia and Heart's Content, and a "Kerrison's regulator" at Calais;) and a circuit-breaking clock. Upon all the chronographs one pen, which is constantly tracing a line upon a revolving cylinder, records the signals, both of the clock and of the observer, by offsets from this normal line.

At Valencia, observations were obtained on fifteen nights, on no one of which was the sky unclouded. "On only two of the five nights on which longitude signals were exchanged with Newfoundland, was it possible to obtain observations after the exchange, and this was possible, too, on only one of the three nights, when signals were successfully exchanged with Greenwich. Fifty-three complete transits were observed over all the threads; on and after November 5th, by Mr. Mosman alone; on the 25th and 28th October, by Dr. Gould; at other times by both. The clock corrections, however, whenever possible, were deduced from Mr. Mosman's observations; when otherwise, a constant correction of $-0^s{\cdot}08$ was applied to Dr. Gould's. For both clock correction and azimuth, the conditional equations were solved by the method of least squares, a method introduced into this branch of the coast survey work by Dr. Gould, and an important means of giving precision to the telegraphic longitudes. We are indebted, indeed, to this eminent astronomer for the particular notation and methods of observation and reduction, which have been employed in the longitude work of the coast survey since it came under his charge, and which are described in the C. S. Report for 1856. The transit observations are given in full, with their reductions for the groups immediately preceding and following the longitude-signals, and with the normal equations and resultant values for each group.

A glance at these observations reveals at once, in the small residuals, both the accuracy of the star-places and the skill of the observers. For, necessarily, different sets of fundamental stars for clock and instrumental corrections were employed at the two stations, owing to their distance, and also at the same station on different nights, owing to the various hours at which the signals could be exchanged. Considering all the unfavorable circumstances, the degree of precision attainded is certainly remarkable. This must be attributed, in great part at least, to the extreme accuracy of Dr. Gould's own carefully elaborated catalogue of fundamental stars, prepared in 1862, for the use of the longitude parties of the Coast Survey, and in its second edition, furnishing still more precise places, especially for circumpolar stars.

The observations at Heart's Content, and at Calais, for time and instrumental corrections, were made, as at Valencia, in very unfavorable circumstances, yet, similarly, exhibit remarkable accordance. Fortunately, at the former place excellent series of transits were obtained, both before and after every exchange of longitude signals, whether with Valencia or with Calais. At the latter place, however, the clock gave serious trouble as well as the weather; yet the observations, though not as good as could be wished, proved to be much more accordant than might have been expected in the circumstances, and give, it appears, a small probable error of the final result.

Longitude signals were successfully transmitted between

Foilhommerum and Heart's Content on but five dates; October 25th and 28th, and November 5th, 6th, and 9th. The method of giving and receiving these signals is thus described in the Report. We quote at length, that a clear understanding may be obtained of that portion of the operations on which the precision of the result chiefly depends.

"Three series, of two sets each, were exchanged on every occasion; each set consisting of ten signals alternately positive and negative, at intervals of about five seconds, except that the fifth and eighth were preceded by pauses of ten seconds, which was also the interval between the two sets. The purpose of this arrangement was to discover whether the velocity of transmission was perceptibly affected by a longer time being allowed for the cable to recover its electrical equilibrium, and also to facilitate the identification of the individual signals. Some slight convenience in the practical details also arose from the circumstance that each set occupied one minute, and that each series consisted of ten positive and ten negative signals. Those signals were considered positive by which the platinum was put in connection with the cable and the zincode with the ground.

In receiving the signals, the observer (Mr. Dean at Newfoundland, and myself at Valencia) watched the deflections of the light-spot, while his thumb rested on the button of a delicately adjusted break-circuit key, which was pressed at the instant in which the deflection was perceived. This instant was thus recorded upon the chronograph, after a certain amount of delay, which we will call the personal error of noting, and which depended upon a considerable number of influences to be discussed hereafter. The keys by which the signals were transmitted were made by the American Telegraph Company, under the supervision of Mr. Dean, and are constructed according to the arrangement devised by Prof. Thomson for the Atlantic Telegraph, in such a manner that pressure upon one button produces a positive, and upon the other a negative signal, while no current flows at other times. To this arrangement an additional contrivance was applied by which the local circuit to the chronograph passed through the same key, and was interrupted by pressure upon either button, so that every signal transmitted through the cable was recorded upon the chronograph at the station whence it was sent.

It is thus manifest that the times of sending the signals were accurately recorded, while the times of receiving signals were recorded after an interval of time dependent on the personal error of noting, and inseparable from the time of transmission through the cable, except by some independent means of measurement. If this interval were the same for both observers, it would be eliminated entirely from the longitude and merged with the time of transmission. Otherwise it would effect the resultant longitude by one-half the difference between the personal errors of noting for the two observers. Happily it proved to be very nearly the same for Mr. Dean and myself, and also measurable; so that it has been possible to eliminate its influence from the measure of velocity, as well as from the longitude."—*Rep.*, p. 54.

The relations of the several quantities derived from the observations, and entering into the final results, are expressed in the following equations: in which T and T' denote the clock times at Valencia and Newfoundland, respectively, Δt and $\Delta t'$ the clock errors, x the transmission time of the signals, and λ the longitude; these quantities being also distinguished by a subscript $_1$ and $_2$ for Valencia and Newfoundland signals respectively. Including in x the personal error of noting signals, the signals given and recorded at Valencia at the time T_1 will be registered upon the Newfoundland record at $T_1'=T_1+\Delta t_1-\Delta t_1'-\lambda+x_1$ and the signals given and recorded at Newfoundland at T_2 will be registered upon the Valencia record at $T_2=T_2'+\Delta t_2'-\Delta t_2+\lambda+x_2$. Thus the comparison of the records of Valencia signals, at the two stations gives $T_1-T_1'=\Delta t_1'-\Delta t_1+\lambda-x_1$, while the comparison of the records of Newfoundland signals gives

$$T_2-T_2'=\Delta t_2'-\Delta t_2+\lambda+x_2,$$

and consequently

$$2\lambda=(T_2-T_2')+(T_1-T_1')+(\Delta t_2-\Delta t_2')+(\Delta t_1-\Delta t_1')+(x_1-x_2)$$
$$x_1+x_2=(T_2-T_2')-(T_1-T_1')+(\Delta t_2-\Delta t_2')-(\Delta t_1-\Delta t_1')$$

If we assume the personal error of noting to be the same for the two observers, and the signals to travel with equal velocity in the two directions, the term x_1-x_2 will disappear from the first equation, while the second will give a measure of the sum of the transmission-times and the personal errors of noting.

The several quantities above indicated are given in detail in the Report for the different series of signals, and exhibit excellent accordance in the results. There appears to have been no difference of clock rates to affect the deduced value of x, nor of velocity for eastern and western signals to require a correction of λ depending on the clocks.

The resultant values for the longitude, subject, however, to a correction for personal equation in determining time, are as follows:—

1866, October	25,	$2^h\ 51^m\ 56^s.477$
	28,	56·487
November	5,	56·455
	6,	56·481
	9,	56·460

The mean interval between the moments of giving the signals and of their record upon the chronograph sheet is similarly found to have been

October	25,	$0^s.62$ ±	$0^s.008$
	28,	0.64	.010
November	5,	0.59	.004
	6,	0.55	.007
	9,	0.54	.005

in which the quantities appended are the probable errors of the respective determinations as deduced from the total results of the several sets, there being six sets for each determination except that of November 6th.

Between Heart's Content and Calais the clock signals were much less satisfactory; being obtained only on four nights, on only two of which the clock errors could be determined either immediately before, or soon after, the exchange, and on one of these two there was special trouble from the clock. By some misunderstanding, also, the signals were not exchanged strictly according to programme, and thus a further source of uncertainty was introduced from the partial confusion occasioned in the record, and the greater difficulty of eliminating personal equation. The resulting longitude and time of transmission exhibit, however, better accordance than was to have been expected, and are as follows (subject to a correction for personal equation):

1866.		λ.	x.
December 11,	0^h 56^m	$37^s.89$	$0^s.24$
12,		37.53	0.31
14,		37.84	0.27
16,		37.78	0.28

From the description of the mode of receiving signals, quoted on page 236, it will be seen that there is introduced, in all the observations, a special error due to the different methods employed at the two stations of recording a given signal. This is called in the report, "the personal error of noting." It is the interval between the arrival of the signal at the galvanometer and its record on the chronograph; for it will be remembered that the signal sent through the cable does not pass at once, automatically, to the chronograph, as at the transmitting station, but reaches it only through the mediation of an observer, who, after noticing the deflection of the light-spot from the galvanometer, sends a second telegraphic signal to his own chronograph. The whole interval, x, therefore, which elapses between the giving of a signal at one station and its chronographic record at the other, is made up of several parts.

These parts, as given in the Report, consist of the time requisite,—

1. For the signal to arrive at the other station.

2. For the galvanometer needle to move through a perceptible arc.

3. For the observer to notice the motion and tap his break-circuit key.

4. For this observation-signal to be recorded upon the chronograph.

Of these the second and third constitute the "error of noting," which is, therefore, partly instrumental and partly personal; the one due to the inertia of the galvanometer-magnet, the other being the "transmission-time" along the nerves from eye to brain, through brain, and thence to finger-tips; consisting, therefore, of three distinct intervals, viz.: 1, between phenomenon and perception; 2, between perception and volition; 3, between volition and giving signal. The sum of these three intervals, according to the experiments made by Dr. Gould, could hardly exceed, for good observers, $0^s.3$; which would give for velocity of transmission through nerves about 13 feet, unless, indeed, some considerable time is occupied in the act of volition after perception, as seems probable from the experiments of de Jaager and Hirsch. Helmholtz made the velocity of nerve-sensation in the frog (dead), by different experiments, 87 and 89 feet per second. Dr. Schelske found that velocity in the nerves of common sensation and along the spinal cord in living men, to be about 97 feet. Others make the velocity not more than half as great.

With respect to the four intervals which make up the quantity x, it is remarked that, if equal at the two stations, they become wholly eliminated in the resultant longitude; if unequal, the longitude must be increased by one half the excess of their sums for westward signals. In either case, the operations for longitude give only their total sum at the two stations. The chronographs at both stations being similar, it might be presumed that the time lost by both in making the record after the key is tapped would be the same; and repeated examinations showed that this was sensibly the case. It therefore becomes eliminated in the resultant longitude; as does also the transmission-time through the cable, if sensibly the same in both directions; as Dr. Gould shows that it is.

The method employed for determining the "error of noting" was alike ingenious and successful. It was by carefully observing a series of signals similar to those exchanged for longitude, and so arranged that both the original signal and the observation of the consequent deflection were recorded on the same chronograph. The similarity requisite in respect to intensity of current, was secured by an ingenious adjustment of battery force to both galvanometer and chronograph, by means of a divided circuit, the branch of it through the galvanometer being a German silver wire so fine as to give an intensity, as compared with that in the other branch, of 1 to 100; the requisite reduction. Other equally skillful devices secured similarity and freedom from error in other respects.

These experiments showed the range of variation of this error of noting for different individuals to be very small; the mean error for Dr. Gould at Valencia being $0^s.271$, and for Mr. Dean at Newfoundland, $0^s.335$; the difference being due to the galvanometer, probably, rather than the observer. The sum of the two $0^s.606$, is the quantity to be deducted from the value of $x_1 + x_2$ to obtain the true time of transmission, and half their difference, or $0^s.032$, that to be deducted from the longitude after all other corrections are applied.

In conducting these experiments a very curious source of error was detected, in the effect of hearing the click of the key, upon observations supposed to depend only on seeing the deflection of the needle. This is a point of so much importance to observers, that we quote the suggestion of the Report, "that a very marked effect upon the observation of transits of stars is likely to be produced when the chronograph is in the same apartment, so that the regular beats of the magnet are audible. When the intervals between the transit-threads are approximately multiples of half a second, the tendency is very great so to tap upon the observing key as to produce a rhythmical beat in the armature; and when the interval differs from the multiple of a second, the occurrence of that magnet-beat which records an even second often precipitates the tap of the observer, whose nerves are in keen tension awaiting the instant of bisection. Only a strong effort of will can obviate these perturbing influences—which are akin to those exhibited in the measurements just described."

This curious effect seems to show that eye and ear do not report to the brain with the same promptness, and that, when addressed simultaneously, the mind cannot recognize which makes the report, but takes that of one or the other, or both together, indiscriminately, the range of uncertainty being equal to the difference in promptness of the two senses. Possibly part of the effect may be due to a definite lapse of time between the occurrence of the audible and the visible signal; which, however, should give a more constant effect.

Want of space compels us to pass the interesting chapter on "Personal equation in determining time," with simply the remark that the ordinary methods of measuring that equation being inapplicable, by reason of the distance and other circumstances, comparisons were made between the observers for this purpose as soon as practicable after their return; and the values deduced, though in many respects quite unsatisfactory, were adopted as the best approximation that could be obtained for the different observers. They are these:

Gould—Mosman	$=+0^s{\cdot}02$
Dean—Mosman	$=+0{\cdot}11$
Goodfellow—Dean	$=+0{\cdot}14$
Boutelle—Goodfellow	$=-0{\cdot}14$
Boutelle—Chandler	$=-0{\cdot}04$

A special arrangement, by which it was intended to entirely eliminate personal equation at Heart's Content, unfortunately failed through some misapprehension of the observers. The fact, however, that they had been in the practice of observing together for many years and had always found the equation between them to vary between very narrow limits, on the two sides of zero, rendered the failure of little practical consequence.

We hasten to give briefly the final results for longitude.

Between Foilhommerum and Heart's Content we have for the several dates, after corrections applied:—

1866, Oct.	25,	$2^h\ 51^m\ 56^s{\cdot}457$
	28,	·468
Nov.	5,	·455
	6,	·481
	9,	·460

The final longitude deduced, after correction for personal equation in determining time, Dean—Mosman $=+0^s{\cdot}11$, and in noting signals, Dean—Gould $=+0^s{\cdot}03$, becomes

$$\lambda=2^h\ 51^m\ 56^s{\cdot}54$$

Between Heart's Content and Calais, the results, similarly corrected, are for the several dates:—

Dec. 11,	$0^h\ 55^m\ 37^s{\cdot}93$
12,	[37·53]
14,	37·84
16,	37·82

And the final result, corrected by $-0^s{\cdot}14$ for personal equation between Boutelle and Goodfellow, and omitting Dec. 12, is—

$$\lambda=0^h\ 55^m\ 37^s{\cdot}72$$

Between Greenwich and Foilhommerum, the longitude was obtained by satisfactory signals on two nights, and compared with two previous determinations by Mr. Airy for other points at Valencia, by short geodetic connections. The two nights exchanges gave

		λ.	α.
1866, Nov. 5,	0^h 41^m	$33^s{\cdot}305$	$0^s{\cdot}115$
13,		33·280	0·110
Mean,	0 41	33·29	

This differs by $-0^s{\cdot}10$ from that adopted by Mr. Airy as deduced from the great chronometric expedition of 1844, and the telegraphic determination of 1862.

The combination of the three longitudes thus determined, gives—

Greenwich—Foilhommerum,	0^h	41^m	$33^s{\cdot}29$
Foilhommerum—Heart's Content,	2	51	56·54
Heart's Content—Calais,	0	55	37·72
Greenwich—Calais,	4	29	7·55

"The Valencia observations having been made by, or referred to, Mr. Mosman throughout the whole period, his personal equation is eliminated; the equation between Messrs. Goodfellow and Dean, always small, may be regarded as trustworthy, and by a happy coincidence the personal equations of Mr. Boutelle on the west, and of Mr. Mosman on the east, seem to be almost identical, so that even a total disregard of this quantity would have resulted very nearly in its perfect elimination, the oceanic arc being diminished and the land arc increased, each by about $0^s{\cdot}14$."

The only probable influence of personal equation in the entire longitude-measurement, comprising, as it does, three-sixteenths of the whole circumference, lies in the difference between the observations of Messrs. Dunkin and Boutelle.

The longitude of Calais, as heretofore telegraphically determined, is as follows:—

Calais—Bangor,	0^h	6^m	$0^s{\cdot}31$
Bangor—Cambridge,	0	9	22·99
Cambridge—New York,	0	11	26·07
New York—Washington,	0	12	15·47
Calais—Washington,	0	39	4·84

whence we have

Greenwich—Washington, 5^h 8^m $12^s{\cdot}39$

The Seaton Station being $12^s{\cdot}44$, and the dome of the Capitol $10^s{\cdot}17$, east of the Naval Observatory, to the center of the dome of which the preceding value refers, we have as their longitudes from Greenwich—

Seaton Station,	5^h	7^m	$59^s{\cdot}95$
Capitol,	5	8	2·22

From the facts, as exhibited in this report, there would seem to be every reason to believe that this result is within a very small fraction of a second of the exact longitude, and that the small probable error, whatever it may be, is mostly due to the weakest link in the whole chain—that between Newfoundland and Calais.

The indiscriminate mean of all the chronometer determinations, as given early in this article, using the numbers of chronometers as weights, is $5^h\ 8^m\ 12^s{\cdot}14$; leaving out Bond's first discussion of the 175, it is $5^h\ 8^m\ 12^s{\cdot}37$. The mean of Peirce's two from occultations of Pleiades, without regard to weight, is $5^h\ 8^m\ 12^s{\cdot}29$.

We regret that we have not room for even a brief abstract of the valuable closing chapter on the transmission-time of signals, but are compelled to dismiss it with barely stating the general result and some conclusions with respect to a few points, as derived from the experiments.

The transmission-time by cable, after correction for personal error in noting signals ($0^s{\cdot}303$), was found to be for the several dates:—

1866, October	25,	$0^s{\cdot}314$	Cable of 1865, with earth and condenser.
	28,	·343	" " " " " "
November	5,	·280	Both cables, no earth.
	6,	·248	" " " "
	9,	0·240	" " " "

The battery-strength on these nights was as follows:—

October	25,	10 cells at Valencia,	10 cells at Newfoundland.
	28,	10 " " "	10 " " "
November	5,	3 " " "	3 " " "
	6,	3 " " "	10 " " "
	9,	4 " " "	10 " " "

From these results the inferences seem warrantable, 1st, that the velocity of transmission is greater when the circuit is direct and consists of a good metallic conductor exclusively, than when the signals are given by induction, although the earth may be at the other electrode; and 2d, that an increase of intensity in the electromotive force is attended by an increase in the velocity of propagation of the signal.

From the observations for longitude, and from other experiments made with special reference to particular points, the following general conclusions were reached.

"It appears manifest that not an electrical charge or discharge, but simply an electrical disturbance, is requisite for transmitting a signal; that an inductive impulse, sufficient to deflect the galvanometers employed, was transmitted through one cable, having at each end a condenser with 10 cells, in somewhat less than the third of a second, five seconds after the transmission of an impulse of the opposite sort; that with a circuit formed by the two cables, a smaller electromotive force sufficed to transmit the signals with yet greater rapidity; that the signals traveled more rapidly through a cable which had not recovered its electrical equilibrium after a current of the opposite character; and that the speed of the signals is modified by the earth-connections, more readily than by changes in the battery-power. And the very marked differences, found in the rates of transmission, between signals given by completing an interrupted circuit and those given by interrupting a closed circuit, may perhaps lead to investigations which will afford an explanation."

C. S. LYMAN.

ART. XXVIII.—*Meteors of November*, 1869; compiled by H. A. NEWTON.

THE cloudy weather in most parts of the United States and Europe prevented continuous observations of the November meteors, at the time of their return in 1869, by nearly all those who were watching for them. The observers, in the few stations where the skies were clear, furnish, however, ample testimony to the appearance of unusual numbers on the morning of Nov. 14th. The display, moreover, like that of 1868, continued for several hours. I give below the particulars of the observations at various places.

1. *At New Haven.*—Two members of the Junior Class, Messrs. C. B. Dudley and R. P. Maynard, saw, through openings in the clouds, six meteors, between 4^h and 5^h on the morning of the 14th. Some of them had the peculiar trains belonging to the November meteors. On the next morning, Nov. 15th, the sky was nearly overcast, but between 3^h and 3^h 45^m, we saw eight meteors, four of them conformable. During the rest of the morning the sky was overcast, and even in this interval it was at no time more than one third clear.

2. A similar failure, nearly or quite complete, is reported by Prof. Eastman, at the U. S. Naval Observatory, Washington, by Mr. Marsh and Mr. Taylor, at Philadelphia, by Mr. Fuertes at Stamford, Conn., by Mr. Boerner, at Vevay, Ind., by Prof. Rockwood at Brunswick, Me., and by various others who were in readiness to make observations.

3. *At Pensacola, Florida.*—To the courtesy of Commodore Sands, Sup't. of the U. S. Naval Observatory, we are indebted for a letter of Commander Wm. Gibson, from Pensacola. He says that the night of the 13th–14th was exceedingly bright and

clear, and that the shooting stars were observed in extraordinary numbers, from 1^h 15^m, A. M., until dawn, most numerously between 3^h and 4^h, A. M. It was difficult to give the average per minute. It varied from two or three to twenty or thirty, or more, the star-showers flashing and intermitting like the bursts and pauses of a gusty rain. In magnitude they varied from mere moving points of light, to those which were larger than Jupiter. One train remained visible at least 50 minutes, drifting slowly to the northward.

4. *Upon the Pacific Ocean.*—To the courtesy of the Secretary of the Smithsonian Institution, we are indebted for a letter of Mr. Alexander Evans of Elkton, Md.

On the morning of Nov. 14th, he was upon the Pacific Ocean, lat. 8° 30′ N., and long. 84° 30′ W. He watched from two till four o'clock, when the sky became overcast. Between these hours the sky was partly covered. The display was, he says, quite equal to that of 1868 which he observed throughout. He thought that the radiant point was not as last year, in the center of the sickle in Leo, but a little more to the eastward between the stars η and γ. There were several nonconformable meteors whose radiant seemed to be the zenith.

5. *At Santa Barbara, California.*—To the courtesy of Prof. Peirce, Superintendent of the U. S. Coast Survey, we are indebted for the observations of Mr. Geo. Davidson, Assistant, and Mrs. E. Davidson at the Coast Survey station, at Santa Barbara (lat. 34° 24′, lon. 7^h 59^m). Between 1^h 18^m, A. M., and 3^h 43^m on the morning of Nov. 14th, they counted 556 meteors. The following table represents the number of meteors seen by the two observers *per minute.* They are taken from the diagram forwarded by Prof. Peirce.

1^h	23^m	2·2	meteors.	2^h	16^m	5·0	meteors.	2^h	46^m	3·0	meteors.	3^h	15^m	5·0	meteors.
	35	3·6	"		21	5·2	"		51	4·0	"		21	2·5	"
	47	4·8	"		25	5·0	"		55	6·0	"		25	2·0	"
	53	5·0	"		31	2·2	"	3	1	6·0	"		31	3·7	"
	59	3·8	"		35	2·2	"		5	3·0	"		35	3·2	"
2	9	4·8	"		41	6·6	"		11	2·0	"		41	4·0	"

Mr. Davidson says, "the night was beautifully clear, the moon being ten days old, and 4° south. I was called at 1^h 10^m, A. M., up to which time 22 meteors had been seen. After 3^h 43^m, A. M., watch was kept for any unusual display, but the numbers gradually diminished. Some of the meteors were very brilliant and left persistent trains. About half a dozen meteors were observed moving in directions toward the radiant.

"At 2^h 33^m, A. M., I observed a brilliant meteor start from a point above, and a little to the left of the pointers; it left a persistent train and disappeared at a point about 9° or 10° above Polaris, and 6° to the right. The train was 5° in length;

gradually it took a wavy form; then curved until it formed two-thirds of an irregular circle, and was 3° in diameter and half a degree in width. I examined it with a good binocular, and found it not of uniform density, but having open spaces in it. It remained visible 8½ minutes, and in that time apparently moved in a line toward the radiant point in Leo, over a space of 8°."

The small number of meteors reported above as seen between 2^h 30^m and 2^h 40^m was due to Mr. Davidson's being engaged in watching the train of this meteor.

At 1^h 15^m Mr. S. R. Thockmorton, Jr., saw a meteor appear and disappear without apparent motion. It was about two degrees above and to the left of the bright star in the blade of the sickle.

6. *At Fredericton, N. B.*, (lat. 46° 3′, lon. 66′ 45′).—A watch was kept up by relays of students of the University of New Brunswick, throughout the night of Nov. 13th, 14th. They report the times and general directions of the individual meteors, with duration of flight, brilliancy, &c. The following table of the numbers seen in each 10 minutes of the night is compiled from their report.

Number of meteors seen at Fredericton, N. B. on the night of Nov. 13th, 14th.

Hour.	0^m–10^m	10^m–20^m	20^m–30^m	30^m 40^m	40^m 50^m	50^m 60^m	Total.
7— 8				1	1	1	3
8— 9	1	1	3	1	0	1	7
9—10	0	0	1	1	1	2	5
10—11	4	0	4	3	2	5	18
11—12	8	12	4	6	6	3	39
12— 1	10	6	4	5	8	26	59
1— 2	6	18	6	8	12	17	67
2— 3	11	10	26	32	37	20	136
3— 4	24	44	23	55	21	14	181
4— 5	22	30	28	35	34	18	167
5— 6	25	31	20	16	22	20	134
6— 7	7	30	4				14
				Total in 11 hours,			830

The observations were made by three parties, each watching for two successive hours. Messrs. Byers, Crozier, Stone, Connell and Williston watched from $7\frac{1}{2}^h$ to 9^h and from 1^h to 3^h.

A second party, consisting of Messrs. Vanwarts, Cliff, Wortman, Belyea, and Lawrence, watched from 9^h to 11^h and from 3^h to 5^h, and a third party consisting of Messrs. Willbur, Scovil, Chandler and Walker watched from 11^h to 1^h and from 5^h to $6\frac{1}{2}^h$. Only four persons were, however, observing at any one time.

7. *In England.*—The clouds prevented observations for most of the time in Great Britain. At Glasgow, Mr. A. S. Herschel

and Mr. Robert McClure had a tolerably clear sky from half past 4 till half past 5.

"Meteors of the brightest class of the November shower, having luminous streaks, were crossing the sky at the rate of about 40 in an hour, for one observer, corresponding to a rate of frequency of at least one hundred per hour, in all the sky. The apparent paths of thirty of these meteors were recorded upon a map, by their course among the stars, and the direction of their flight was from the usual radiant point in the constellation Leo. * * * *

"A clear view of the sky was again obtained towards eleven o'clock on Sunday night, when a single shooting star, passing from Gemini to Taurus, and leaving a faint streak, appeared to be the last visible representative of the November meteors. Although the sky continued clear, and an attentive watch was kept for nearly three hours afterwards, no other meteor could be seen. The purely negative character of this result adds a fresh proof to the evidence obtained in former years of the definite boundaries and narrow limits between which the stream of the November meteors is confined."

Observations at Greenwich and at most other places in England were not successful on the morning of the 14th.

At Culloden, Mr. A. Forbes counted upwards of 200 between the hours of 3^h and 7^h, A. M., the maximum of the shower appearing to be about 5 o'clock.

8. *In France*, the "Association Scientifique" organized a system of observations, at various stations near the Mediterranean, embracing even one or two in Italy. The results were to be reported and discussed at sessions to be held in the latter part of the month of November, at Marseilles and Bordeaux. We have not learned what success rewarded the zeal of the French observers.

9. *At Paris.*—Mr. Chapelas reports to the French Academy of Sciences, that notwithstanding unfavorable weather and moonlight, "observations conscientiously made, give us for the mean hourly number reduced to midnight and to clear sky, and corrected for the influence of the moon, for the night of Nov. 12th, 6·8 meteors; for the night of Nov. 13th, 24·8 meteors."

He says that the observations for the preceding nights gave steadily, a smaller hourly number than the mean for that period of the year, which is, according to him, 13·6.

Mr. Chapelas, as usual, does not say how many meteors he saw, nor how long he observed, nor how large a correction he applies for cloudiness, nor what for moonlight, nor what to reduce to midnight. We are not aware, even that he has published rules or constants for such reduction. His *observations* might perhaps have some value, if we knew what they were.

They could then be criticized, and compared with those of other observers. If found to have been carefully made they would be valuable to science. But as now given to the world, the observations of Mr. Coulvier-Gravier and Mr. Chapelas are inextricably mixed up with their deductions. The manifest errors of the latter taint the whole, and make it necessary to throw them all away. The French Academy of Sciences publishes his reports, and we respectfully call its attention to the matter.

10. *At Vienna.*—Prof. Weiss of the Observatory of Vienna, with three aids, determined 36 paths with the meteoroscope between 2^h and 6^h, A. M., of the 13th (Prof. Schmidt in *Heis Wochenschrift*, Dec. 8th). Some of them were from the Leo radiant. The total number visible was verv moderate.

The next night was stormy, and for an interval of 10 minutes only at 4^h, A. M., could anything be seen. A few stars of Leo, Gemini and Auriga were then visible through openings in the clouds, and along with them, though principally seen through haze, were some meteor tracks, having trains and radiating from Leo. Prof. Schmidt estimated that the hourly number for one observer was about 50, reckoning only the brighter meteors, and considered the display not greatly different from that seen by him at Athens in 1863.

At Munster and elsewhere in northern Germany the sky appears to have been overcast.

11. *At Rome.*—The cloudy skies which covered northern Europe on the night of the 13th, 14th, also impaired the Italian observations. Padre Secchi reports a few, though incomplete, from Rome.

At 2^h 30^m A. M. the clouds broke away in the west and in five minutes 18 meteors were seen. At 2^h 35^m the sky was nearly clear except low in the northeast, and a regular count was begun.

From 2^h 35^m to 2^h 40^m, 29 meteors were seen; from 2^h 40^m 2^h 48^m, 41; from 2^h 48^m to 3^h 0^m, 73; from 3^h 0^m to 3^h 15^m 40. At 3^h 18^m it became again overcast. The whole number in 40 minutes was 183, of which 5 were unconformable. He omits to state the number of observers. Padre Secchi concludes:

1st. That there was a real recurrence of the display.

2d. That it was but little different from the display last year, there having been then seen in the same interval about 200 meterors. The hour moreover was not that of the maximum.

3d. That the radiant point was within the bend of the sickle in Leo, and made with the stars ε and μ an equilateral triangle. But this determination was not very precise owing to the want of tracks near the radiant.

4th. That the greater part of the meteors passed to the north of the radiant.

It was further remarked that the trains were visible only a few seconds, and that there were none of the beautiful scrolls of smoke which were seen last year.

Madame Scarpellini gives in her *Corrispondenza Scientifica* accounts of observations at Rome by herself, (with negative results) and the following from Perugia and Civita Vecchia.

12. *At Civita Vecchia.*—Prof. Pinelli reports to Madame Scarpellini the following observations from Civita Vecchia.

Nov. 12th–13th. Between $10^h\ 30^m$, P. M., and 1^h, A. M., 4 meteors seen of 1st magn., 6 of 2d magn., and 8 of the third. Only a few clouds.

Nov. 13th–14th. Between $11^h\ 30^m$ and $2^h\ 35^m$, 54 meteors seen. Very cloudy and finally overcast.

Nov. 14th–15th. Up to $1^h\ 20^m$, A. M., only 16 meteors seen.

13. *At Perugia.*—On the morning of the 13th from 12^h to 6^h, A. M., Prof. Bellucci counted the following numbers in the several hours; viz., 26, 22, 26, 28, 24, and 17. In all 138 in six hours.

On the next night in successive hours from 6^h, P. M., till 4^h, A. M., he saw 3, 1, 0, 2, 1, 2, 0, 39, 190, 246. During the next half hour 71 were seen, making 555 in all. From $4^h\ 30^m$ it was overcast.

14. *At Velletri.*—Prof. D. Ignazio Galli, of the Municipal Observatory at Velletri, watched during the two nights of the 12th and 14th of November. (*Bull. Met. Rom.*)

On the first night, two observers, with a clear sky, in five hours, from $12^h\ 45^m$ till $5^h\ 45^m$, saw 71 meteors. The distribution through the five hours was as follows:

From $12^h\ 45^m$	to $1^h\ 45^m$,	2 conf.,	9 unconf.
" $1^h\ 45^m$,	" $2^h\ 45^m$,	5 "	7 "
" $2^h\ 45^m$,	" $3^h\ 45^m$,	8 "	6 "
" $3^h\ 45^m$,	" $4^h\ 45^m$,	7 "	7 "
" $4^h\ 45^m$,	" $5^h\ 45^m$,	11 "	9 "

On the second night they were able to see only through openings in the clouds. There were three or four observers, enough to fully command the whole of the visible portions of the sky. The results were as follows:

Time.				Meteors seen. Conf.	Unconf.	Portion of sky visible.	Total computed for clear sky.
1^h	0^m,	1^h	15^m	50	1	0·2	255
1	15	1	30	48	1	0·2	245
2	0	2	15	41	6	0.4	117
2	15	2	30	31	7	0·3	126
2	30	2	45	43	4	0·4	117
2	45	3	0	62	8	0·5	140
3	0	3	15	17	4	0·2	105
Total in $1^h\ 45^m$,				292	31		

The meteors of this second morning were much finer than those of the preceding morning. The sporadic meteors of each night appeared to radiate from Auriga.

15. *From Moncalieri.*—Director F. Denza reports in *Les Mondes*, for four observers:

Night of the 12th of Nov. from	14^h	to	17^h	145 meteors.
" 13th "	9		17	720 "
" 14th "	$14^h\ 10^m$		$17^h\ 10^m$	99 "

These numbers need to be increased, as their principal object was to determine the position of the tracks and the instant of appearance of the meteors.

On the night of the 13th, 14th, there were seen:

At Alexandria by	4 observers from	$9^h\ 45^m$	to	$16^h\ 45^m$,	168 meteors,
At Aosta,	1 "	$14^h\ 30^m$		18^h	189 "
At Varallo,	1 "	$13^h\ 25^m$		$16^h\ 25^m$,	121 "

Prof. Denza adds that "the meteoric shower of Nov. 1869, differs little from that of August, and in some places was even inferior to it."

16. *At Port Said, Egypt.*—In the *Monthly Notices* for Dec. are some observations of G. L. Tupman, Esq., at that place. On the mornings previous to that of the 13th, he detected some tendency to radiation from Leo. On that morning, of thirteen meteors, four were conformable.

On the morning of the 14th from $12^h\ 30^m$ to $13^h\ 15^m$ only two meteors were seen, neither conformable. There was a pretty large patch of clear sky overhead.

"The watch was resumed at $14^h\ 30^m$, the sky being then partly clear in patches, and continued until a quarter past 5, long before which the shower had entirely ceased. At $2^h\ 30^m$ it was at its height, most of the meteors being remarkably brilliant, and many of them tinted green. The greater part left bright streaks, which often remained visible a considerable time. The duration of the meteors or their 'time of flight' was considered to be less than half a second—too short a time to estimate even roughly.

"The following are the observations. Being unassisted, I stopped at every sixteenth to make the necessary entries.

"If the numbers in the table be reduced to an uniform interval of time and then multiplied by the cosecant of the altitude of the radiant, it will be seen that between $14^h\ 30^m$ and $16^h\ 24^m$ the numbers were nearly uniform, and slightly decreasing. The maximum, then, was either before or about $14^h\ 30^m$; but the *center* of the dense part must have been passed about 15 hours, as there was no sign of the shower at $13^h\ 15^m$.

Meteors observed at Port Said, Nov. 13th, Alexandria mean time.

From h	m	To h	m	No. of Meteors.	Elevation of the Radiant.
10	40·0	13	15·0	0	15
14	30·0	14	40·0	16	35
14	52·0	15	2·5	16	40
15	8·0	15	19·7	16	43
15	24·0	15	33·6	16	46
15	38·5	15	52·5	16	50
15	59·0	16	7·4	16	54
16	12·0	16	24·0	16	57
16	26·0	16	38·0	6*	60
16	40·0	16	52·0	7	63
16	54·0	17	14·0	4	67

Seven other meteors were observed, but they did not radiate from Leo.

From 11 orbits he determined $\alpha=151°·0$, $\delta=21°·5$, measured from the equinox of 1869. No single point satisfied all the paths that were observed.

The conclusions of Mr. Tupman respecting the closing of the shower are of course set aside by the observations in Italy and England by those of Fredericton and Santa Barbara.

17. The duration of the whole shower was at least twelve hours,and it appears to have been somewhat fitful in its intensity. Perhaps the apparent fitfulness may be due to the clouds, though we think that that is not the only reason.

Thus after the time named by Mr. Tupman we have an increasing display shown by Prof. Bellucci's numbers. At Culloden the report seems to carry this display on two hours longer. The numbers seen at Fredericton and Santa Barbara show a tolerably uniform continuance for several hours longer. There was little trace of the display on the next morning.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *On Ammonia-chromium bases.*—Cleve has communicated to the Royal Swedish Academy of Sciences a memoir on the ammonia-chromium bases, which, though of not very recent date, has not, we believe, been noticed either in German or in English journals. The author sets out with the chlorid discovered by Fremy and investigated to some extent by himself in a previous memoir. To this he gives the formula, Cr_2Cl_3, $4NH_3$, $2HO$, and the name tetramin chrom-chlorid. It will be sufficient for our purpose to give

* During this observation it was more cloudy than before, but during the two following ones it was much clearer.

the formulas of the various compounds with a general account of their properties. The formulas of the salts described by Cléve belonging to the tetramin series are as follows:

Chlorid,	Cr_2Cl_3, $4NH_3$, 2HO.
Chlorplatinate,	Cr_2Cl_3, $4NH_3$, $2HO+2PtCl_2$.
Chlorhydrargyrate,	Cr_2Cl_3, $4NH_3$, 2HO+6HgCl.
Chlorobromid,	Cr_2ClBr_2, $4NH_3$, 2HO.
Bromid,	Cr_2Br_3, $4NH_3$, 2HO.
Bromochlorid,	Cr_2BrCl_2, $4NH_3$, 2HO.
Chloro-iodid,	Cr_2ClI_2, $4NH_3$, 2HO.
Iodid,	Cr_2I_3, $4NH_3$, 2HO.
Chlorosulphate,	Cr_2ClO_2, $4NH_3 2SO_3$, 2HO.
Bromosulphate,	Cr_2BrO_2, $4NH_3 2SO_3$, 2HO.
Chlorochromate,	Cr_2ClO_2, $4NH_3 2CrO_3$, xHO.
Chloronitrate,	Cr_2ClO_2, $4NH_3$, 2NO5, 2HO.

All these salts are crystalline and easily soluble in water. They have a carmine red or garnet red color and their solutions are easily decomposed on heating, with separation of chromic oxyd and evolution of ammonia. The author calls attention to the very noteworthy fact that they all contain 2 atoms of water (in the old notation).

The second series of compounds described are the salts of heptamin-dichromium.

The formulas of the only observed members of this series are as follows:

Double nitrate,	$2(Cr_2O_3, 3NO_5), 7NH_3+NH_4O, NO_5+9HO$.
Oxalo-nitrate,	$2(Cr_2C_3, NO_5, (C_2O_3)_2), 7NH_3+6HO$.

The salts of the triamin series are as follows:

Oxalate,	$Cr_2O_3, 3C_2O_3, 3NH_3, 3HO$.
Double oxalate,	$2(Cr_2O_3, 3C_2O_3, 3NH_3)+NH_4O, 2C_2O_3, HO+3HO$.

The salts of the heptamin and triamin series resemble those of the tetramin series so closely as not to require special description. The nitrate of the heptamin series is obtained by the action of nitrate of silver upon the chlorid of tetramin-chromium. The oxalate of the triamin series is obtained by the action of oxalic acid upon the same chlorid. Besides these three series the author describes the following salts, which may obviously be regarded as members of other and analogous groups.

$$Cr_2O_3, NO_5, 2NH_3+3HO.$$
$$Cr_2O_3, C_2O_3, NH_3+8HO.$$
$$2(C_2O_3), SO_3, 2NH_3+24HO.$$

It is, however, very doubtful whether these three substances were obtained in a state of purity, as they were all amorphous and could not be obtained crystallized.—*Kongliga Svenska Vetenskaps-Akademiens Handlingar, Ny Följd*, 1866, 7 vol., 2d half.

W. G.

[*Note.*—The compounds described by Cleve are of especial interest when considered from an atomistic point of view. The formulas of the triamin and tetramin series are of course to be doubled and we should then have for the three chlorids the empirical formulas

$6NH_3$, Ꞓr$_2$Cl$_6$	Hexamin-chromium chlorid.
$7NH_3$, Ꞓr$_2$Cl$_6$	Heptamin-chromium chlorid.
$8NH_3$, Ꞓr$_2$Cl$_6$	Octamin-chromium chlorid.

Adopting Blomstrand's view of the constitution of the analogous platinum and cobalt compounds, these three bodies may be written as follows:

$$\text{Ꞓr}_2^{vi}\left\{\begin{array}{l}-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\end{array}\right. \text{'} \quad \text{Ꞓr}_2^{vi}\left\{\begin{array}{l}-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\\-NH_3-NH_3-\text{Ꞓ}l,\\-NH_3-Cl\\-NH_3-Cl\end{array}\right. \quad \text{Ꞓr}_2^{vi}\left\{\begin{array}{l}-NH_3-Cl\\-NH_3-Cl\\-NH_2-NH_3-Cl\\-NH_3-NH_3-Cl\text{'}\\-NH_3-Cl\\-NH_3-Cl\end{array}\right.$$

Cleve suggests that the heptamin series may be only double salts of his tetramin and triamin compounds, and in view of the unsymmetrical structure of the chlorid this seems at least probable. It is also to be borne in mind that the want of symmetry is only seen if we adopt Blomstrand's theoretical views, and does not appear when the ammonia bases are formulated according to the principles of variable atomicity supported by the writer.* The invariable occurrence of two atoms of water in all the octamin compounds is difficult to explain upon any theory.—W. G.]

2. *On some new sulphur salts.*—Schneider has described some new sulphur salts belonging to the same class with those which we have already noticed. Potassio-platinous sulpho-platinate is easily obtained by fusing 1 or 2 parts of platinum sponge with 6 parts of pure potassic carbonate and six parts of sulphur, and treating the cooled mass with water. The author gives to this salt the formula:

$$K_2S, Pt''S, Pt''S, \} Pt^{iv}S_2$$

and points out its analogy to a copper salt described in a previous paper. The new compound forms small, hard, sharp and distinctly formed, six-sided tables of a blue gray color and strong metallic luster. The larger tables have a reddish tint and in thin layers are translucent with a red brown color. The density of the salt is 6·44. Dilute chlorhydric acid slowly dissolves out the potassium without the slightest evolution of sulphuretted hydrogen, the final product of the reaction being sesqui-sulphid of platinum Pt_2S_3 or platinous sulpho platinate PtS, PtS_2. This is a steel gray crystal-

* This Journal, vol. xlix, p. 108.

line powder of density 5·52, which when heated in the air burns like tinder and leaves pure spongy platinum. Sodio-platinous sulpho-platinate has a precisely analogous formula, sodium replacing potassium. It is a crystalline powder of density 6·27 and with a color between blue-gray and reddish lead-gray. A re-examination of the compound containing tin, platinum, potassium and sulphur, described in his previous paper, has led Schneider to the conclusion that this body contains no oxygen, and that its true formula is

$$K_2S, Pt''S, Pt''S, Pt''S \} Sn^{iv}S_2,$$

in which the quadrivalent platinum is replaced by quadrivalent tin. In addition to the sodium salt corresponding to the compound last formulated, Schneider describes a disodium salt which has the formula

$$Na_2S, Na_2S, Pt''S, Pt''s \} Pt^{iv}S_2.$$

When freshly prepared, this salt forms thin brilliant light copper red needles. It rapidly changes color in the air and becomes brown and finally almost black. Water dissolves it with partial decomposition, leaving a dark red crystalline powder of bisulphid of platinum. Schneider obtained by double decomposition silver and thallium salts corresponding to the disodium compound.—*Pogg. Ann.*. cxxxviii, 604. W. G.

3. *Synthesis of Hydroxylamin.*—By the action of tin and chlorhydric acid upon ethylic nitrate Lossen obtained the chlorhydrate of a new base, $NH_3\Theta$, which he termed hydroxylamin. Ludwig and Hein have succeeded in preparing this body by the direct addition of nascent hydrogen to nitric oxyd, expressing the reaction by the equation:

$$N\Theta + H_3 = NH_3\Theta,$$

which is more correctly written $2N\Theta + 3H_2 = 2NH_3\Theta$. The nitric oxyd was prepared by the action of nitric acid upon ferrous sulphate and collected in a glass gasholder from which it was made to pass through a series of flasks containing tin and boiling chlorhydric acid. After separating the tin and ammonic chlorid the chlorhydrate of hydroxylamin was obtained with all the properties described by Lossen.—*Berichte der Deutschen Chem. Gesellschaft, 2ter Jahrgang*, p. 671. W. G.

4. *On a new group of double chlorids belonging to the platinum bases.*—By adding solutions of various metallic chlorids strongly acidulated with chlorhydric acid to a solution of the chlorid of Reiset's first base, PtCl, $2NH_3$ or $4NH_3$, $PtCl_2$, $PtCl_2$, Buckton obtained a series of double chlorids embraced by the general formula $4NH_3$, $PtCl_2$, $PtCl_2$. Thomson has found that a second series of double chlorids of the same quantitative constitution but with wholly different properties is obtained by adding an ammoniacal solution of a metallic salt as copper, silver, nickel, &c., to a solution of double chlorid of platinum and ammonium, $PtCl_2$, $2NH_4Cl$. The new salts are crystalline and vary in color according to the metal used; they are insoluble or with difficulty soluble in water and ammonia, but dissolve rather easily in dilute chlorhydric acid and are precipitated from this solution by ammonia. Buckton's salts are soluble in water and insoluble in chlorhydric acid.

W. G.

5. *A system of instruction in Quantitative Chemical Analysis;* by Dr. C. R. FRESENIUS, from the last English and German editions, edited by Prof. S. W. JOHNSON of Yale College. 8vo, pp. 631. New York: (John Wiley & Son). 1870.—In explanation of the alterations made in this American edition we quote the following from Prof. Johnson's preface.

"In preparing this edition of Fresenius' Quantitative Chemical Analysis, the editor has sought by various changes to adapt it to the wants of the American student.

The foreign editions have attained such encyclopedic dimensions as to occasion the beginner no little confusion and embarrassment. For this reason the bulk of the work has been considerably reduced. A few processes which the editor's experience has convinced him are untrustworthy, and many more that can well be spared because they are tedious or unnecessary, have been omitted.

The section on Organic Analysis has been reduced from sixty to thirty pages, mainly by the omission of processes which from their antiquity or inferiority are more curious than useful. The chapters on Acidimetry and Alkalimetry have been likewise greatly condensed, and all that especially relates to Soils and Ashes of Plants has been left out. The recent appearance of an excellent special treatise on "Agricultural Chemical Analysis" by Professor Caldwell, of Cornell University, justifies the last named omission.

On the other hand, some important matter has been added. Bunsen's invaluable new methods of treating precipitates are described in his own (translated) words. Various new methods of estimation and separation are incorporated in their proper places.

The additions which have been made to the methods of examining ores, it is believed, adapt the work to meet all the ordinary requirements of the metallurgical and mining student."

The editor acknowledges his indebtedness to Dr. Wolcott Gibbs, Dr. J. Lawrence Smith, Mr. O. D. Allen and others for important contributions and descriptions of new methods. We are confident that this excellent work will be of great service in advancing the study of analytical chemistry in this country, and that its publication will be welcomed by all teachers and students of quantitative chemical analysis.

6. *Effects of the Sun's Heat on a Sand Hill.*—Extract from a letter of GEO. DAVIDSON, Esq., of the Coast Survey, dated U. S. Coast Survey Station, San Buenaventura, Cal., January 23d, 1870, (communicated for this Journal, by Mr. D. B. Smith, of Germantown, Pa.)—I have had a very curious experience at this station. It is on the edge of a sandy, steep bluff, seventy feet above the low flat margin that extends 300 yards to the sea beach. At the station, I had an 18 inch theodolite, with three reading microscopes, and was engaged in determining the azimuth of the principal lines of the triangulation from the station San Buenaventura. This involved observations from sunrise to 10 A. M., and from 3½ P. M. to 11 P. M. Imagine my surprise when I found that the heat of the

sun pouring all the P. M. upon the southwest face of this bluff so expanded it that the level showed changes as great as 45″! Then in the evening contraction began, and continued until the level at sunrise exhibited changes of 45″ the other way. Here *was a change of* 1′ 30″ *certainly due to changes of temperature;* our lowest temperature was about 40°; our greatest about 79° in the shade, say 100° in the sun.

But this is not all: I was dismayed to find that in cooling during the evening, the tongue of the bluff upon which the station is situated, *twisted irregularly* in azimuth as much as 18″ in three hours. This, of course, vitiated all my results, and I continued a full series simply as an experiment, for I could not change my position for an eccentric one without many drawbacks. I did change my latitude instrument and transit from their positions near the station, and where the same phenomena were exhibited by them. At 102 yards from the edge of the bluff they are as steady as a rock, and I have nothing but the excessive undulations of the heated air to contend with.

7. *On the existence of Ammonium in the Ammoniacal Amalgam, and on a new Test for the presence of Nascent Hydrogen;* by ALBERT H. GALLATIN, M. D., of New York.—Berzelius and De Pontin in 1808, using the voltaic current as Davy had done, endeavored to do as much for the ammoniacal compounds as he had done for those of the fixed alkalies. They made what is known as the ammoniacal amalgam. That ammonium exists in this body has never been demonstrated, notwithstanding that its constituents in their proper proportions were always found escaping from the amalgam: that does not prove thea they were united; on the contrary, 2 vols. of NH_3 and 1 vol. of H are the products. Moreover, if it were ammonium, it had never been made to unite with any other metal than mercury. I have endeavored to overcome both of these objections.

If the hydrogen escaping from the mercury together with the ammonia can be shown to be in the nascent state, it would be evidence that it had just been in chemical combination with the ammonia, in other words, that metallic ammonium (NH_4) existed in the amalgam. Some pellets of sodium were placed in contact with some particles of the transparent variety of phosphorus, wrapped in bibulous paper and plunged beneath the surface of water. A red glow was seen; and the nascent hydrogen from the decomposing water came into contact with the phosphorus, bubbles of phosphid of hydrogen were formed. Occasionally one would flame as it came into contact with the atmosphere, placing the nature of the reaction beyond doubt. As phosphid of hydrogen cannot be formed by direct synthesis if ordinary free hydrogen be employed, this becomes a test for the presence of that gas in its nascent state. The hydrogen escaping from the ammoniacal amalgam was now tested by this process. A sodium-amalgam dipped beneath a solution of chlorid of ammonium was employed; and it became necessary to wait until the sodium was exhausted, that results might not be vitiated by the nascent hydrogen escaping from the water. At the proper time the decomposing amalgam was covered with fragments of transparent phosphorus, when many bubbles of inflammable phosphid were obtained. The hydrogen must then have been in the nascent state and just escaping from the ammonium.—*Phil. Mag.*, xxxviii, 57.

8. *On the Existence of an Alloy of Ammonium and Bismuth, and on another new Test for the presence of Nascent Hydrogen;* by ALBERT H. GALLATIN, M. D., of New York.—Ammonium had never yet been seen united with any other metal than mercury. Mercury being the only metal fluid at ordinary temperatures, should another alloy be formed it would be solid. Some bismuth was melted in a porcelain dish and alloyed with sodium by dropping a piece of that metal on the clear surface of the fluid bismuth. Chlorid of ammonium was then dusted on the fluid alloy, and then water added in a fine quick stream. The bismuth swells, appears pasty and porous, and then congeals. Abundance of hydrogen escapes from the water, and the ammoniacal odor is set free. This body must now be dried. If it be placed near the ear a distinct crackling noise will be heard, a phenomenon which endures for some days. To ascertain if this be ammonium escaping from the bismuth, the body was placed beneath the surface of water, when bubbles of hydrogen escaped, easily to be collected and recognized; the ammonia, if any, must have been absorbed by the water. To test for this red litmus-paper was placed in the liquid. Wherever the currents from the bismuth struck it a blue spot became visible. On dissolving sulphate of copper in distilled water and placing the well-dried bismuth therein, the characteristic flocculi of ammonio-sulphate of copper appeared at once.

It remains to show that the hydrogen escaping is in the nascent state. There was not enough of it to test wlth phosphorus. The bismuth compound, when placed in a solution of sulphate of copper, becomes rapidly coated with metallic copper. Now bismuth unalloyed will not precipitate copper from its sulphate. To test if the precipitation of the metallic copper was due to the presence of nascent hydrogen, an alloy of bismuth and sodium was made and dipped in a solution of sulphate of copper. It instantly became coated with that metal, owing to the nascent hydrogen escaping from the water. The hydrogen was therefore escaping in the nascent state from the bismuth and ammonia, and therefore it was a true alloy of bismuth and ammonium. If the temperature of this alloy be raised, it will rapidly decompose with a crackling noise. On one occasion it exploded, sharply scattering the metal. The loud crackling noise produced by this substance may be heard for many days after it is made. That there is no mere surface-action in the case of the mercurial and bismuth alloys of ammonium, is shown by the pores which are formed by the escaping gases in both cases. In the amalgam these pores may be seen produced by the escaping ammonium long after the water has exhausted the sodium. In the mercurial body the pores are evanescent; in the case of bismuth they remain, and may be examined at leisure.

These are different phenomena from those displayed by spongy platinum when it forces hydrogen and oxygen to combine.

Appendix.—Continuation of the investigation at the laboratory of the Royal Mint, London, by the kind permission of Mr. Roberts:—

The alloy was dried *in vacuo* over sulphuric acid. It was then heated *in vacuo* by means of a Sprengel pump, when it decomposed, and the resulting gas was collected over mercury. It was found to have twenty-seven times the volume of the original solid. Analysis of the gas proved it to contain nitrogen and hydrogen. The results of a further examination will shortly be given.—*Phil. Mag.*, IV, xxxviii, 58. June 23, 1869.

II. MINERALOGY AND GEOLOGY.

1. *Preliminary Field Report of the U. S. Geological Survey of Colorado and New Mexico*, conducted, under the authority of Hon. J. D. Cox, Secretary of the Interior, by F. V. Hayden, U. S. Geologist. 156 pp. 8vo. Washington, 1869.—Prof. Hayden, in this expedition of the year just past, was over his old field again, in which he has done so much by his observations and collections to promote the progress of American geology and paleontology. His explorations, however, were continued farther west, to and among the heights of the summit. His route was from Cheyenne, where he commenced his labors, to Denver; from Denver to the silver mines at Georgetown, the gold mines of Central City, and thence to the Middle Park; then back to Denver, and southward to Colorado City, Soda Springs, Cañon City, Spanish Peaks, Raton Hills, Fort Union, Mora Valley, and Santa Fé; thence up the Rio Grande, through the San Luis valley, Poncho Pass, Arkansas Valley, through the South Park to Denver again. Prof. Hayden remarks that "the coal formation along the base of the mountains was studied with great interest. With these coal beds are associated valuable deposits of brown iron ore. The coal and iron deposits of the Raton Hills extend from the Spanish Peaks to Maxwell's, and the supply of both is quite inexhaustible and of excellent quality. The future influence of these two important minerals at this locality, on the success of a Pacific Railroad, cannot be over-estimated. It is believed that the coal and iron mines of the Raton Hills will be of far more value to the country than all the mines of precious metals in that district.

The next locality for coal was at the Placiere Mountains. In one locality here, the coal has been changed into anthracite by the eruption of a basaltic dike, the igneous material of which had poured over the coal strata. Vast quantities of brown iron ore are associated with this coal, and magnetic iron ore is found in the gneissoid rocks of the mountain. The gold mines here are very rich and are now wrought upon a true scientific plan."

As this Report consists of field notes, the geological facts are present as they were observed along the principal routes; and we shall wait for a systematic review of the results from the author before presenting them, and cite in this place only some of the paragraphs from his account of the trip to the famous "Middle Park."

Our route to the Middle Park was through the Berthoud Pass, from the valley of Clear Creek. The range of mountains in which the pass is located is composed of gneissic rocks—as are all the ranges in the mining districts. The ascent was very steep on the south side, up to the region of perpetual snow; but the descent on the north side is quite gradual.

Great quantities of loose materials from the basis rocks are scattered thickly over the summits, of every variety of the metamorphic class. Most of the peaks are well rounded, and covered with soil and vegetation. Grass and flowers grow far up above the limits of arborescent vegetation. As we ascend, the pines, spruces and cedars dwindle down in size, until they become recumbent and trail on the ground. Some of the highest peaks are very sharp, and covered with loose rocks, as if only the usual atmospheric influences had ever affected them. Their sides are often massive escarpments of rocks down which an infinite quantity of fragments have fallen, making a vast amount of debris at the base. Of course their rocky sides are entirely free from vegetation, and the oxyd of iron gives them a rusty reddish appearance. One mountain at the head of Clear Creek is called Red Mountain, from the fact that the rocks have a bright red color in the distance. The evidences of the outpouring of igneous rocks in this mountain are very marked; indeed, it may be called an eruptive range.

From the summit of Berthoud's Pass, at a height of eleven thousand eight hundred and sixteen feet, we can look northward along the line of the main range, which gradually flexes around to the northwest, while the little streams seem to flow through the rifts. The general appearance of the western slope of this great range would indicate that it is a huge anticlinal, composed of a series of ranges on each side of a common axis, and then smaller ranges ascend like steps to the central axis. The western side of this ridge slopes gently, while the eastern side projects over abruptly. This main range also forms a narrow dividing line, or "water-divide," between the waters of the Atlantic and Pacific. I stood where the waters of each side were only a few feet apart, and felt a real joy in passing down the western slope of the mountain by the side of a pure crystal stream whose waters were hastening on to the great Pacific.

The Middle Park is really made up of a number of smaller parks, which are somewhat independent of each other. Each one may present different geological formations. The little park on the south side, which we first enter, is a very beautiful one. The grass is luxuriant, and the timber excellent. None of the older sedimentary rocks were seen along the flanks of the mountains, but a recent tertiary deposit seemed tô cover the country. On the east side of Fraser Creek there is a long high ridge, which is cut by the stream in several places, formed of the white and yellow sands and marls which mark the pliocene tertiary on the east side of the mountain. I have no doubt that it is a formation of the same kind as that of the Arkansas marls, and cotemporaneous with it.

Along this creek there are some massive walls of this formation, mostly yellow marls, but some layers of sandstone. This ridge extends from the mountains far northward, and is about two miles wide; and between it and the immediate base of the mountains is situated a beautiful valley of considerable width.

The Middle Park is apparently a quaquaversal, surrounded by the lofty snowy ranges; and the lower ranges descending like steps to the valley which constitutes the true park. The park does not appear to be more than from ten to twenty miles wide from east to west, and from fifty to sixty long from north to south. In this park, also, the ranges of mountains so surround it that the slopes seem to form a sort of quaquaversal inclining toward a common center.

Viewed from Middle Park, Long's Peak, and the range immediately connected with, has a rugged, saw-like edge, as if composed of eruptive rocks, and ridge after ridge inclines from it in regular order.

About ten miles north of our camp, in the first park, we come to low ridges of massive red feldspathic granite, and parallel with these granite ridges are a series of sedimentary beds, commencing with the brick-red beds. The strike is nearly north and south, and the dip west. These ridges are all so grassed over that the true nature of the underlying rocks is not easily determined. Then comes ridge after ridge, untill all the beds—jurassic and cretaceous—are shown.

On this stream we have a fine system of terraces. On the north side are three distinct terraces above the bottom, and the lowest one has a bed of cretaceous sandstone, nearly horizontal, cropping out at its base. This is a low one, not more than fifteen feet high; the next one is fifty feet high, and the third, which descends from the high hills, is two hundred feet. A little west of south, at the junction of Grand River with Frazer Creek, five high peaks are visible, which form in that direction a part of the main range. All around us, in every direction, we could see the snowy peaks, and the beds which form the ridges of upheaval inclining in every direction.

To the south of the park, the older sedimentary rocks dip north in lofty ridges, at least two thousand feet high, presenting high escarpments when split by streams, and reaching almost the highest margin of the mountains.

About ten miles above the hot springs, Grand River flows through an enormous gorge cut through a high ridge of basalt, which seems to be an intrusive bed, for above and below the sedimentary rocks are well shown, but partially changed. Underneath are the cretaceous shales of Numbers 4 and 5, and above are the lignite tertiary beds. These beds all dip west 23°.

These eruptive rocks are very rough, as if they had been poured out without much pressure. Much of it is a very coarse conglomerate, the inclosed masses appearing to be the same kind as the paste; that is, originally, of igneous origin. Some of the inclosed rocks are very compact, close, and all were more or less worn, before being inclosed. This rock is a true dolorite. I did not see any inclosed masses that I could call unchanged. This basalt extends a great distance, continuing a nearly uniform thickness, and inclining in the same direction with the cretaceous beds below and the tertiary beds above.

On both sides of Grand River, but especially on the east and northeast sides, extending up nearly to the foot of Long's Peak, are quite large exposures of the recent tertiary beds. They are nearly horizontal, and have much the appearance in color of the Fort Bridger beds, of which Church Buttes is an example. These beds are composed, for the most part, of fine sand and marl, but there are a few small rounded boulders scattered through it. Below the gorge, on the north side of Grand River, these outflows of basalt have formed some well-defined mesas; at least three beds, ascending like steps from the river. The basalt lies in horizontal beds, but on the south side is the sloping side of a basaltic ridge. The dip is nearly northwest, though the trend of this basaltic ridge is by no means regular. One portion of it has a strike northwest and southeast, and another north and south. The tertiary rocks reach a great thickness, and are elevated high up on the top of the basaltic ridge, eight hundred to one thousand feet above the river. They are mostly formed of fine sandstone and puddingstone. These fine sandstones contain some well-marked impressions of deciduous leaves, among which are good specimens of *Platanus haydeni*. On the north side of Grand River, in some localities, the tertiary beds are elevated so high, on many of the eruptive mountains, that they are covered with perpetual snow. These eruptive beds are certainly among the most remarkable examples of the overflow of igneous matter that I have ever seen in the West. * * * *

Immediately below the hot springs the Grand Cañon commences, and the river cuts its way through an upheaved ridge of massive feldspathic granite, for three miles, between walls from one thousand to one thousand five hundred feet high. The south side is somewhat sloping, and covered thickly with pines, while the north side is extremely rugged, the immense projecting masses of granite forbidding any vegetation to gain a foothold. It would seem that the river had worn its way through a sort of rift in the granite, but at the upper end it has cut through the uplifted sedimentary ridges nearly at right angles. In some places the north side is gashed out in a wonderfully picturesque manner, so that isolated columns and peaks are left standing, while all the intermediate portions have been worn away. This granite ridge will average perhaps five miles in width, and extends an unknown distance across the park, northeast and southwest, and it is from the southeast side that the ridges of upheaval, above described, incline.

The granite ridge seems to form a sort of abrupt anticlinal. On the southeast side the rocks all are bare, or covered with a superficial deposit of recent tertiary marls. None of the older unchanged rocks are seen on this side, but the modern sands and sandstones are exposed in a horizontal position in the channel of the river.

The hot springs are located on the right bank of Grand River, at the juncture of the sedimentary rocks with the granites. Just east of the springs is a high hill, Mount Bross, one thousand to one thousand two hundred feet above Grand River, which seems to be composed mostly of the older tertiary strata, alternate yellow and gray sandstones, and laminated arenaceous shaly clays. The whole is so grassed over, that it is difficult to take a section. The beds incline east of north at a small angle. I regard the beds as of the age of the coal formations of the West, older tertiary. I found excellent impressions of deciduous leaves, among which are those of the genus *Magnolia*. Just opposite the springs, the left bank of the river shows a perfect section of all the layers, from the cretaceous to the jurassic. The bank is not more than ten feet thick above the water, and yet it shows that the river itself rolls over the upturned edges of all these beds.

The section in descending order is as follows:

1. *Tertiary* strata, forming the greater part of the hill known as Mount Bross. The *Cretaceous*, consisting of—

2. Gray laminated sandstones, passing down into arenaceous clays, with *Baculites ovatus*, &c.

3. Black clays of No. 4. These are of great thickness, and every variety of texture. As shown in a cut bank of the river, it is yellow a enaceous clay, with layers of sandstone, in which the impressions of deciduous leaves were observed. These layers project up, a distance along the bank, of seventy paces.

4. Dark plastic clay, with cone in cone, seams of impure clay, iron ore. Then comes an interval in which no layers could be seen, sufficient to include No. 3—two hundred and fifty paces.

5. Dark steel-black laminated slate, with numerous fish scales; dip twenty-seven degrees. This slate passes down into alternate layers of rusty sandstone and shaly clay. * * * *

I have given this detailed description of the cretaceous rocks to show the exceeding variableness of their texture, and also to call the attention of scientific men, who may hereafter visit this interesting locality, which will soon become celebrated, to a section of the rock through which the waters of the spring must pass in reaching the surface. Now, in whatever rocks these springs may originate, the water must pass a long distance through the almost vertical strata of the Cretaceous period, in the sediments of which are found in other localities nearly all and perhaps all the mineral constituents found in these springs. The deposits around these springs are very extensive. No analysis has as yet been made, but large masses of gypsum and native sulphur can be taken out at any time from the sides of the large basin-like depression into which the water flows. They are properly "Hot Sulphur Springs," varying in temperature from 80 to 112°.

Troublesome Cañon, at the head of the creek bearing this name, is entirely basaltic, and the rugged walls, not only of the main stream, but also of the little branches, form a most picturesque view.

Below the Cañon, the valley of Troublesome Creek, and also that of Grand River near the junction, is occupied by belts of modern tertiary sands and marls, like those observed at the entrance to the park, by Berthoud's Pass. Where the little stream cuts the terraces, horizontal strata of whitish and flesh-colored sands and marls are exposed. I looked in vain for fossils, and found only specimens of silicified wood. There are cold sulphur springs in this valley. All through the park, the benches or terraces are conspicuous in the vicinity of streams, as at the base of mountain ranges. In the park through which Frazer's Creek flows, these benches or terraces are most beautifully carved out from the modern marls.

In summing up the geology of Middle Park, we find that all the sedimentary rocks known in this country are found there. I did not see any beds that I could define as carboniferous, but the triassic, jurassic, cretaceous, and tertiary are well developed. I have no doubt as to the existence of true carboniferous limestones in the Middle Park.

The tertiary deposits of this region may be divided into two groups, viz., the lignite or older tertiary, and the modern pliocene marls and sands, which seem common to the parks and mountain valleys. The former conform perfectly to the older beds, while the latter seldom incline more than three to five degrees, and do not conform to the older rocks. The marl group is undoubtedly contemporaneous with the Arkansas and Sante Fé marls.

This volume contains also a valuable Report of P. Frazer, Jr., on the mines and minerals of Colorado, and another by Cyrus Thomas, on the agriculture of Colorado.

2. *The Gold Fields and Mineral Districts of Victoria, with Notes on the Modes of Occurrence of Gold and other Metals and Minerals;* by R. Brough Smyth, F.G.S., &c., Secretary for Mines for the colony of Victoria, Melbourne. 644 pp. Royal 8vo. 1869. (Trübner & Co.)—We have examined this elaborate volume with equal pleasure and instruction. It is, in fact, an extensive treatise, full of minute details and exact information rendered in an unpretending matter of fact style. The work is illustrated by plans, sections, sketches, diagrams and maps, and is carefully printed and accompanied by ample tabular statements, statistical and otherwise.

Perhaps the most striking thing brought to light by the Victoria gold fields, to one who is also familiar with those of California, is the fact that, to all appearance, the area of the Australian fields yet unexplored, or very imperfectly so, is vastly greater than any reserves known to exist upon the Pacific slopes of North America. Of a minimum of 20,000,000 acres of known gold fields in Victoria, not more than 600,000 acres, or one thirty-third part, have been opened and explored, while many of the older districts are still yielding, with improved methods and economy, better results than at any former period. The fact of the general similarity of the modes of occurrence of gold in gulches, deep lying placers, and in old river courses, under lava, and basalt, in Australia and California, has long been known, but the subject receives new and valuable illustration by the labors of Mr. Smyth. Hitherto comparatively little has been known in this country respecting the modes of occurrence and productiveness of the gold-quartz mines—*reefs*, as they are called—in Victoria. This want Mr. Smyth fully supplies. He tabulates the course and direction of nearly 500 quartz veins in the several mining districts, the directions being from N. 89° W. to N. 47° E.; but by far the greater number of veins run about N. 30° to 40° W.; and mention is made of results obtained from the workings of over 2400 mining companies, mostly engaged upon quartz. The number of quartz reefs (veins), actually proved to be auriferous, is over 2,600, and the total extent in square miles of auriferous alluvial and quartz ground worked upon is upwards of 880 square miles.

The average yield of gold from certain parcels of quartz, the details of which are given from 1859 to 1868, from returns made to the Mining Surveyor and Registrars, is shown to be from 5,816,669 tons 9 cwts. of quartz crushed, 3,346,201 oz. 8 dwts. of gold or an average, per ton of 11 dwts. 12·37 grains. This value is very unequally distributed between the different districts, as appears from an inspection of the details tabulated in the appendix. The average fineness of the Australian gold is considerably above that of California.

Full and very interesting details are given of several of the most important quartz mining operations, of which the Port Philip Co., at Clunes, is the most important. The following is a return of quartz crushed at Clunes for the 12 months ending September, 1865, viz.: 54,413 tons of quartz crushed yielded 20,596 oz. 10 dwts. 12 grains of gold, averaging 7 dwts. 13 grains per ton, and valued at $20 per oz.=$417,920. To crush this amount of quartz, 80 stamps were required, viz.: 56 heads of about 6 cwts., each striking 75 blows per minute, requiring about one horse power each, and crushing an average of about 2 tons, 4 cwts. each; while 24 stamps weighing about 8 cwts. each, crush 4 tons per diem each of fine material; about 8 gallons of water per head per minute is required by these stamps, or 921,600 gallons per diem. Two steam engines drive the stamps. Of the total gold saved, 66·08 per cent are found in the stamp beds, 22·95 in the mercury-boxes, and 10·97 comes from the blankets.

Compared with the best California mines, the yield per ton of the St. Philip, is small. Thus in 1868–9, 20,638 tons of gold quartz crushed at the Eureka Mill, Grass Valley, California, yielded $537,-687.89, or an average of $27.80 per ton of ore; and this is considerably less than the average of some former years. The average of the Amador Company, Sutter Creek, on a somewhat greater crushing is over $25 per ton, and has steadily increased from $5 or $6 to the present rate in sinking to a depth of 1200 feet, which is double the depth of the St. Phillips, at Clunes.

Mr. Smyth discusses at length Sir Roderick Murchison's notion that quartz gold veins become poorer in depth, and effectually proves that there is no evidence of this; but after a careful comparison of over 200 examples, he announces the following general conclusions: 'Taking the whole of the information and results obtained into consideration, there is much reasonable evidence produced in support of the theory *that quartz reefs are richer as they increase in depth*, and in addition to this, *that they are wider.*'

A remarkable feature of the Australian gold fields, in which they are distinguished above all others, is the magnitude and frequency of the nuggets found in them. Mr. Smyth gives two interesting tabular statements of remarkable nuggets, the history of which is known, as compiled by Mr. Birkmyre, an experienced assayer, and the second by Mr. F. Knox Orme, the warden of Dunolly. Of Mr. Birkmyre's list (over 150 specimens), only 27 are American or European. We enumerate a few of the most remarkable Australian nuggets, compiled from both tables:

	lbs.	oz.
Dunolly, date, &c., unknown,	248½	
The "Welcome Stranger Nugget," found Feb. 2d, 1869, in the auriferous alluvium, near Bull Dog Reef, Dunolly, Victoria; 21 inches long, 10 inches in thickness; mixed with the quartz, but the great body of it solid gold; 986 fine; value £9534. The neighborhood of Dunolly is almost an unprospected country. For many miles there are out-cropping reefs which have yielded very large pieces of gold.	190	10
The "Welcome Nugget," found June 15, 1858, at Bakery Hill, Ballaarat, Victoria, at 180 feet depth; water-worn and irregular shaped; 20 inches long by 12 broad and 7 deep; by assay, 992 fine; value, £9.325.	184	9
The "Blanche Barkly Nugget," found 27th August, 1857, at Kingower, Victoria, at a depth of 13 feet, and within five or six feet of holes dug three years before. It measured 28 inches by 10, and contained about two lbs. of quartz, clay, &c.; assay, 955; value, £6.905.12.	145	3
Found at Canadian Gully, Ballaarat, Victoria, 31st of January, 1853, at a depth of 60 feet; 989 fine; value, £5.532 7s. 4d.	134	11
Found in July, 1851, by a native boy, in a heap of quartz at Meroo Creek, River Turon, 53 miles from Bathurst, N. S. W. It was in three pieces when found, though considered as one mass.	106	
Found in 1857 at Dunolly, Victoria, two specimens with gold distributed through a rust-colored matrix.	237	
Found Nov. 1st, 1858, at Burrandong, near Orange, N. S. W., at a depth of 35 feet, mingled with quartz and pyrites; of 874 fineness.	107	2
The "Lady Hamilton Nugget," found 1854, Sept. 8th, near Canadian Gully, Ballaarat, Victoria, at a depth of 135 feet.	98	1

Did space permit, this list might be continued, by far the larger number of nuggets found being under 100 lbs. Troy, and the history of some of them is sufficiently curious. Many of the large nuggets of Australia are distinctly referred to quartz veins in the immediate vicinity, and masses are specified of several pounds weight, which have been found attached to the veins. How rare this circumstance is in California, is well known; the only example of much significance being in the Morgan claim on Carson Hill. The famous Cabarras Co. (N. C.), (1821,) nugget of 34 lbs. weight was alluvial gold. The largest nugget found in California was at Valiceto, (24th April, 1852), near Carson Hill, and weighing 25 lbs. 5 ounces.

The following tables exhibit interesting information.

Returns showing approximately the gold obtained from quartz veins and alluvial workings during the years 1864 *to* 1868 *inclusive, Victoria:*

Year.	From Quartz Veins.		From Alluvial Workings.	
	oz.	dwts.	oz.	dwts.
1864	503,618	5	1,041,076	10
1865	450,000	0	1,093,801	0
1866	521,017	0	958,177	15
1867	560,527	0	873,160	6
1868	587,694	0	1,069,804	0

The ratio of quartz gold to alluvial gold is thus shown to be much higher in Australia than it is in California, where not over one quarter of the annual production is considered to arise from quartz, while in Victoria it is seen to be about one half.

Yield of Gold per annum: Victoria.

Year.	Quantity Exported. ounces.	Value at 80*s.* per oz.
1851 for 3 mos.	145,146	580,584
1852	2,218,782	8,875,128
1853	2,676,345	10,705,380
1854	2,150,730	8,602,920
1855	2,751,535	11,006,140
1856	2,985,991	11,943,964
1857	2,762,460	11,049,840
1858	2,528,478	10,113,912
1859	2,280,950	9,123,800
1860	2,156,660	8,626,640
1861	1,967,420	7,869,680
1862	1,658,207	6,632,828
1863	1,626,872	6,507,488
1864	1,544,694	6,178,776
1865	1,543,801	6,175,204
1866	1,479,194	5,916,776
1867	1,433,687	5,734,748
1868	1,657,498	6,629,992
Totals,	35,568,450	132,273,800

To arrive at the total quantity exported, it is necessary to add 1,267,241 ozs. to the above.

Mr. Smith's volume contains ample material for study, and offers many tempting extracts, but our space compels us to forbear.

3. *On Old Water Courses;* by Dr. J. S. Newberry.—(To the citations from the memoir of Dr. Newberry on Surface Geology at page 111, we here add the following.—Eds.)

"Some of the valleys and channels which bear the marks of glacial action—evidently formed or modified by ice, and dating from the ice period or an earlier epoch—are excavated far below the present lakes and water-courses which occupy them.

These valleys form a connected system of drainage, at a lower level than the present river system, and lower than could be produced without a continental elevation of several hundred feet. A few examples will suffice to show on what evidence this assertion is based.

Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario are basins excavated in undisturbed sedimentary rocks. Of these, Lake Michigan is 600 feet deep, with a surface level of 578 feet above tides; Lake Huron is 500 feet deep, with a surface level of 574 feet; Lake Erie is 204 feet deep, with a surface level of 565 feet; Lake Ontario is 450 feet deep, with a surface level of 234 feet above the sea.

An old, excavated, now-filled channel connects Lake Erie and Lake Huron. At Detroit the rock surface is 130 feet below the city. In the oil region of Bothwell, &c., from 50 to 200 feet of clay overlie the rock. What the greatest depth of this channel is, is not known.

An excavated trough runs south from Lake Michigan—filled with clay, sand, tree trunks, &c.—penetrated at Bloomington, Ill., to the depth of 230 feet.

The rock bottoms of the troughs of the Mississippi and Missouri, near their junction or below, have never been reached; but they are many feet, perhaps some hundreds, beneath the present stream-beds.

The borings for oil in the valleys of the Western rivers have enabled me not only to demonstrate the existence of deeply buried channels of excavation, but in many cases to map them out. Oil Creek flows from 75 to 100 feet above its old channel, and that channel had sometimes vertical and even over-hanging cliffs. The Beaver, at the junction of the Mahoning and Shenango, runs 150 feet above the bottom of its old trough.

The Ohio throughout its entire course runs in a valley which has been cut nowhere less than 150 feet below the present river.

The Cuyahoga enters Lake Erie at Cleveland, more than 100 feet above the rock bottom of its excavated trough. The Chagrin, Vermilion, and other streams running into Lake Erie exhibit the same phenomena, and prove that the surface level of the lake must have once been at least 100 feet lower than now.

The bottom of the excavated channel in which Onondaga Lake is situated, and the Salina salt-wells bored, is at least 414 feet below the surface level of the lake and 50 feet below the sea level. (Geddes. Trans. New York State Agricultural Society, 1859.)

The old channel of the Genesee River at Portage, described by

Prof. Hall in the Geology of the 4th District of New York; the trough of the Hudson, traceable on the sea bottom nearly 100 miles from the present river mouth; the deeply buried bed of the Lower Mississippi, are additional examples of the same kind; while the depth to which the Golden Gate, the Straits of Carquinez, the channel of the lower Columbia, the Canal de Haro, Hood's Canal, Puget Sound, &c., have been excavated, indicates a similar (perhaps simultaneous) elevation and erosion of the Western coast of America.

The falls of the Ohio—formed by a rocky barrier across the stream—though at first sight seeming to disprove the theory of a deep continuous channel in our Western rivers, really afford no argument against it, for here, as in many other instances, the present river does not follow accurately the line of the old channel below, but runs along one or the other side of it. In the case of the Louisville falls the Ohio runs across a rocky point which projects into the old valley from the north side, while the deep channel passes under the lowland on the south side, on part of which the city of Louisville is built.

The importance of a knowledge of these old channels in the improvement of the navigation of our larger rivers is obvious, and it is possible it would have led to the adoption of other means than a rock canal for passing the Louisville falls, had it been possessed by those concerned in this enterprise.

I ventured to predict to Gen. Warren that an old filled-up channel would be found passing around the Mississippi rapids, and his examinations have confirmed the prophecy. I will venture still further, and predict the discovery of buried channels of communication between Lake Superior and Lake Michigan—probably somewhere near and east of the Grand Sable—at least, between the Pictured Rocks and the St. Mary's River—between Lake Erie and Lake Ontario through Canada,—between Lake Ontario* and the Hudson by the valley of the Mohawk,—between Lake Michigan and the Mississippi, somewhere along the line I have before indicated. I also regard it probable that a channel may be found connecting the upper and lower portions of the Tennessee River, passing around the Mussel Shoals. This locality lies outside of the area where the Northern Drift deposits were laid down to fill and conceal ancient channels, but the excavation and the filling up of the channel of the Tennessee—like that of the

* When the water in the lake basin had subsided to near its present level, its old avenues of escape being all silted up by the Drift clays and sands the surplus made its exit by the line of lowest levels wherever that chanced to run. As that happened to lie over the rocky point that projected from the northern extremity of the Alleghanies into the lake basin, there the line of drainage was established in what is now known as Niagara river.

Though among the most recent of the events recorded in our surface geology, this choice of the Niagara outlet by the lake waters was made so long ago that all the erosion of the gorge below the falls has been accomplished since. The excavation of the basin into which the Niagara flows—the basin of Lake Ontario, of which Queenstown Heights form part of the margin—belongs to an epoch long anterior.

Ohio—were determined by the relative altitude of the waters of the Gulf. The channel of the Lower Tennessee must have been excavated when the southern portion of the Mississippi valley was higher above the Gulf level than now, and Prof. Hilgard has shown that at a subsequent period, probably during the Champlain epoch, the Gulf coast was depressed 500 feet below its present relative level. This depression must have made the Lower Mississippi an arm of the sea, by which the flow of the Ohio and Tennessee was arrested, their channels filled, terraces formed, &c. If the Upper Tennessee has, as appears, a channel lower than the Mussel Shoals, it must be somewhere connected with the deep channel of the lower river.

4. *The Volcano of Kilauea, and great Earthquake Waves;* by Rev. TITUS COAN.—I have lately returned from a tour of exploration to the active crater of Kilauea and the volcanic district of Puna. At Kilauea the action was dull. The central area of this immense crater remains a deep concavity, depressed about 400 feet below its margin; but this margin is a new rim or black ledge of lava, itself depressed a thousand feet below the banks of the crater, and marking the former level of its bottom. In this profound basin I noticed a scanty growth of ferns rooted in the superficial strata of lava. They had gone down uninjured to a depth of 400 or 500 feet, as the crust subsided upon the disgorgement of the molten lava beneath. The old South Lake retains its locality; but its contours are entirely changed. It is now a nearly circular pit, about 400 feet deep in the bottom of the crater. Its diameter, as I measured, is four-fifths of a mile, and its walls, of black hardened lava, are jagged and frowning; in some places beetling; in others, perpendicular or retreating. To this abyss access is anything but easy; it is possible to enter it at but a single place, and by making a *trajet* over a steep, rugged, and difficult incline of *debris*, yet a brave American lady of my party ventured to descend under my guidance. Here, 2,000 feet below the surface of the ground, we tramped together over the floor of the awful pit. It seems now the half-cooled forge of Vulcan. The fiery billows no longer roll and break as they were wont to do over this vast area of indurated lavas; yet, in many places we could look into red-hot ovens and chimneys, and down through orifices in the crust to the molten sea below, and hear, and see, and feel the incandescent minerals boiling, and surging, lashing the sides of the deep cavern, and sending up volumes of white sulphur vapors. But now this principal focus of volcanic action is comparatively quiet. Our last great eruption has lowered its fiery tides far below their usual level; and we are content to enjoy this lull in the strife of the telluric forces which are so ably described in Dr. C. F. Winslow's recent work on Force and Nature—a work which gives the completest explanation that has yet appeared of volcanic phenomena in Hawaii. I spent three days at Kilauea, making careful observations of the crater; and, when these were completed, went to the seashore at Ke-a-la-ko-mo, a village in the volcanic district of Puna, situated about twenty

miles from Kilauea. In this district the subsidence of the land was distinctly marked. Throughout a coast line of many miles in extent the shore has settled from six to eight feet.

On the 25th of July last a remarkable flood tide visited the southern shore of Puna, tearing away the faces of the sea-cliffs, sweeping over barriers 25 feet high, rolling in foaming surfs hundreds of feet inland, and carrying with it huge boulders and angular masses of rock of from a ton to three tons in weight. The sea rose nearly *thirty feet* in perpendicular height, or ten feet higher than the great earthquake wave, already described in your Journal, of the 2nd April, 1868. Several houses which were not reached by that wave were swept away on the 25th. By the latter calamity nearly everything has been destroyed upon the high shores of Ka-ha-na-le-a, and the delicious bath in the fissure at Pu-na-luu is doubled in depth. Nor are the changes that the plastic volcanic agency is impressing upon this country yet completed. At Ka-la-pa-na the sea is more and more invading the land. Two channels are opened through the beach, and the tide ebbs and flows over large fields of the Ka-la-pa-na plain. The old stone church of the village is deeply buried in sand and boulders, and the tides sweep entirely over it. From Ka-mai li to Ka-po-ho the shores are terribly torn by the action of the waves. Between the villages of O-pi-hi-kaa and Po-ho-i-ki the waves dashed a thousand feet inland and destroyed a mile of road running parallel with the shore, upon a line never before reached by the sea. But for the declivity of our shores, these gigantic waves would have penetrated much further inland. The point of disturbance, from which these remarkable waves radiated, is still unknown to us. The focus of the great Peruvian earthquakes of 1868 was near the city of Arica, where the first shocks were felt at 4¾ P. M., Aug. 13. The resulting earthquake wave reached our islands, a distance of 6,000 miles to the northwest, late at night *upon the same day*, and, traveling toward the southwest, reached the harbor of Lyttleton, New Zealand, at 4¾ o'clock in the morning of the 15th. Making the allowances in time required by a difference in longitude of 243 deg. 18 min. (counting eastward), it appears that the wave occupied but 19 hours and 17 minutes in making the latter distance of 7,200 miles. This makes 368 miles per hour, or 540 feet per second, about half the nominal velocity of a cannon-ball. On the 23d of December, 1854, a similar wave was transmitted across the entire breadth of the Pacific Ocean, from Japan to California, in 12 hours and 38 minutes. The great earthquake wave of April 20, 1868, passed from our Hawaiian shores to the coasts of Mexico, California, and Oregon, in *five hours'* time, as indicated by self-registering tide-gauges at San Francisco and Astoria, which announced its arrival upon the evening of the same day in which it had desolated the coasts of Puna and of Ka-u. These waves are entirely distinct from the tidal swing of the ocean, and are proper *waves of translation.—N. Y. Tribune.*

I returned to Hilo by the coast-route, experiencing occasional earthquakes by the way, some of them a little startling. These still continue at intervals; but we are inclined to expect a season of comparative volcanic quiet at present, and have no sensation, in the way of natural phenomena, in definite prospect earlier than the transit of Venus in 1874. We are already promised visits by scientific observers upon that occasion.

5. *A Treatise on Ore Deposits;* by BERNHARD VON COTTA, Professor of Geology in the Royal Saxon School of Mines; translated from the second German edition, by FREDERICK PRIME, Jr., Mining Engineer. 594 pp. 8vo. New York, 1870. (D. Van Nostrand).—Mr. Prime has done a good thing for all interested in the study of ore deposits, in giving us a translation of Van Cotta's "Erzlagerstättenlehre." This book has long been the standard authority in Germany, and we are fortunate in now having an edition of it in English, which is even more complete than the last German edition, as Mr. Prime not only had the approval and permission of the author, to translate the work, but Prof. v. Cotta also has made alterations and furnished additions to it, so that it is in reality a new edition. The work commences with a general discussion of the different kinds of metalliferous deposits, covering some 90 pages, and then takes up, by way of illustration, the description of the most important mining districts of Europe, closing with a chapter of theoretical considerations, suggested by the observed facts. We trust that the publication of this excellent work will inspire our mining engineers and geologists with a sense of the importance of carefully observing and recording the facts connected with the occurrence of ore deposits in this country. The work already done by some of our best observers, especially such admirable researches as those of Prof. J. D. Whitney on the Upper Mississippi lead region, shows what may be done. The forthcoming reports of the California survey, and of the survey of the 40th parallel, will undoubtedly furnish a large amount of new material, which, with the facts already published in various geological and mining reports, might form the basis of a work on American "ore deposits," that would very appropriately supplement Mr. Prime's translation of von Cotta's book, and give a still further impulse to this important study.

6. *Notice of Asbestus and Corundum with other Minerals at Pelham, Mass.;* by J. H. ADAMS, Senior in Amherst College.—In the towns of Pelham and Shutesbury, Mass., there are several localities of asbestus, known to the mineralogists in this part of the state, although no special mention is made of them in any scientific work, they being scarcely noticed in the geological survey. Surface specimens of indifferent quality have been common in collections for years. Dark colored pieces, hard and compact, have sometimes passed for petrified wood, to which there is a strong resemblance. The most noted of those localities, is on the land of Mr. Samuel Newell in Pelham. Recent excavations to obtain asbestus for economical purposes reveal its presence here in great

quantity. Much of it is soft, of a grayish-white color, composed of delicate parallel fibers, often one foot in length, with a marked cross cleavage oblique to the fibers, as in hornblende.

Intimately associated with the asbestus, is an altered mica, allied to vermiculite or jefferisite. This appears in irregular veins, separated by a decomposed asbestiform mineral, and granular actinolite, which crumbles upon exposure. It occurs in loose foliated scales and small angular aggregations, occasionally several inches in size. Hardness, about 1·5. Luster pearly, sometimes metallic. Color light brass-yellow to yellowish brown, scarcely transparent, even in very thin folia. Flexible, inelastic. Before the blowpipe exfoliates remarkably, and at last fuses slightly on the edges. This property however is variable. Of five specimens taken, only two exfoliated in a marked degree. The laminæ after heating appear as if melted or pressed together, and not readily separating. It differs in this respect from the jefferisite of Westchester, Pa., but seems to resemble it in optical characters. Both exhibit a six-rayed astersim, although from its extreme opacity a sufficient thin lamina of the Pelham mineral is obtained with difficulty.

These veins of altered mica are free from admixture with soil or other minerals; and the substance is often so loose as to be readily displaced by the hand without the aid of a pick. Farmers use it as an absorbent for bedding cattle. Might it not be of service in other ways?*

Not the least interesting circumstance, however, is the presence at this spot of corundum. Flattened masses of brownish-black mica, superior in hardness to the surrounding mineral, contain nodules of corundophilite which inclose a white corundum. It is often streaked of a deep sapphire blue. This is, I think, the second observation of the kind in northern New England, the other locality being at Chester. It rarely occurs in situ, and in small quantity; but doubtless farther excavations will develop more valuable specimens. The locality promises considerable interest to the mineralogist; and it is believed that the asbestus may prove of sufficient value to warrant mining.

Amherst College, Nov. 13, 1869.

7. *Note on the Remains of Fossil Birds;* by O. C. MARSH.—Just after the article on pages 205 to 217 had gone to press, I received from Professor F. V. Hayden a unique specimen, which forms a most interesting addition to the fossil bird remains there described. It is the distal portion of a large feather, with the shaft and vane in such excellent preservation, that it may perhaps indicate approximately the nature of the bird to which it belonged. The specimen was discovered in a fresh-water Tertiary deposit, of the Green River group, in Wyoming Territory, and will be figured and described in full with the osseous remains noticed in the above article.

* A similar mineral is used in Europe for sanding paper, in place of blotters.

8. *The Dinornis and Saurian remains in Australia;* by Rev. W. B. Clarke.—A femur of a species of Moa or Dinornis has been announced by Rev. W. B. Clarke as found in the Pleistocene drift of Peak Downs, Australia. The femur was probably buried in a fresh water fluviatile drift, over which was formed a lacustrine deposit. Mr. Clarke regards the discovery as evidence of the former connection of Australia and New Zealand, and makes the following additional observations on the subject. "Returning, in conclusion, to the supposed connections, in former geological times, of New Zealand and Australia, a fresh testimony has been offered to me within the last few days, in the statement of a discovery during the last few months of abundant remains of Saurian reptiles along the Waipara River in New Zealand, of the same kind as those which have been found to occur along the Flinders River in Queensland, and which, in addition to the Plesiosaurus discovered by the same friend, Mr. Hood, show that there was a similar geological fauna in times as far back at least, as the Cretaceous period. The Plesiosaurus was mentioned in my paper 'On recent geological discoveries in Australasia' (1861). Although now the flora is dissimilar, yet there is evidence that in even earlier geological times, such as our Carboniferous epoch, for instance, there was a similar flora.

"The views I have adopted lead me to maintain, that we in Australia inhabit only a fragment of a vast continent, of which in New Zealand there was probably, as there still is, the culminating ridge or the highest portion of Pacific dry land. That this opinion is not without support, I find, by a passage in Dr. Mantell's account of his son's discoveries of Dinornis. Without remembering that passage (which, indeed, I am not sure I ever read till this evening), I have expressed myself in language nearly identical with that of Dr. Mantell, who says, in 1850, 'It seems probable that these stupendous animals were not anciently confined within the narrow limits of modern New Zealand, but ranged over a vast continent, that is now *submerged*, and of which the isles of the Pacific are the culminating points.'"

9. *Synopsis of the Extinct Mammalia of the Cave Formations in the United States, with observations on some Myriapoda found in and near the same, and on some Extinct Mammals of the Caves of Anguilla, W. I., and of other localities;* by Edward D. Cope. (From the Proceedings of the American Philosophical Society, Philadelphia, vol. xi, p. 171, 1869.)—This includes an account of remains of mammals discovered in a cave breccia in Wythe county, Virginia, by the author, among which several extinct forms occurred associated with existing species. The new species are *Stereodectes tortus* (gen. et sp. nov.) allied to *Arctomys; Tamias lævidens; Sciurus panolius; Mixophagus spelæus; Galera perdicida.* Associated extinct species are *Megalonyx Jeffersonii; Tapirus Haysii; Dicotyles nasutus; Ursus amplidens,* and others. Among the recent species are *Castor fiber; Neotoma? Floridanaum; Lepus sylvaticus; Cariacus (Cervus) Virginianus; Procyon*

lotor, etc. The species previously described by Le Conte and Leidy, from a similar deposit in the lead-bearing limestone of Galena, Ill., are also included in the list. The whole number of species is 27, of which 14 are extinct and represent 5 extinct genera, while 6 genera are of "neotropical type." Seven species of land shells, and remains of reptiles and birds were also found. The species of *Myriapoda* obtained are enumerated and several new species and a new genus, *Andrognathus*, are described. In the second part of the paper two genera of gigantic rodents from Anguilla are described: *Amblyrhiza inundata* and *Loxomylus longidens.* In connection with these a human instrument of shell was discovered. The third contains descriptions of *Anoplanassa forcipata*, a new genus and species of Cetacea from near Savannah, Georgia, and *Hemicaulodon effodiens*, a large Sirenian allied to the Dugong, from the Eocene Marl of Monmouth county, N. J. V.

10. *The Extinct Mammalian Fauna of Dakota and Nebraska*, including an account of some allied forms from other localities, together with a *Synopsis of the Mammalian remains of North America*, illustrated with 30 plates; by JOSEPH LEIDY, M.D., LL.D., Professor of Anatomy in the University of Pennsylvania; preceded with an introduction on the *Geology of the Tertiary Formations of Dakota and Nebraska*, accompanied with a map; by F. V. HAYDEN, M.D., Professor of Mineralogy and Geology in the University of Pennsylvania, etc. Vol. VII, of 2nd series, of the Journal of the Academy of Natural Sciences of Philadelphia. Philadelphia, 1869.—In this large and beautiful volume, issued by the Academy of Sciences of Philadelphia, Dr. Leidy has given a thorough revision of all his own labors and those of others, with regard to the ancient Mammalian Fauna of the Upper Missouri region. As he observes in his preface, the materials for this work "have been gradually and continuously accumulating for the last twenty-three years." Through the new facts which have come to light, the author has been enabled to revise his former determinations of species, and to write out the characteristics of each with far more precision and fullness. The synonymy is well worked up and contains many points of historical interest. The value of the work is much enhanced by the addition of the "Synopsis of the Mammalian remains of North America," which occupies 84 pages of the volume, and must have cost the author a vast amount of labor. The thirty lithographic plates show exactness in delineation, and illustrate not only the species of the Nebraska region, but also several of those of other parts of the country.

A large part of the personal observations on the geology of the region, and of the collections of its fossils have been made by Prof. F. V. Hayden, and it is therefore especially appropriate that the introductory chapter should have come from his pen. A large colored map of the geology of the region accompanies the work which was also prepared by Prof. Hayden. A further analysis of the work we have to defer to another occasion.

11. *On the Geology of the New Haven Region, with special reference to the orign of its Topographical features;* by JAMES D. DANA. 70 pp. 8vo, with a map. From vol. II, of the Transactions of the Connecticut Academy.—The author concludes, from the facts brought out in this paper, "that, by special facts, and by the course of events, this region in the Glacial era, like that of New England to the North, was moulded at surface largely by the action of the Connecticut valley glacier and its underflowing streams, and covered through the subsequent melting of the ice, with stratified and unstratified drift-formations simultaneously; that icebergs had no part in the matter, and the supposed iceberg sea over New England no existence."

12. *On the Mixture of Cretaceous and Eocene Fossils*; by T. A. CONRAD, (communicated for this Journal).—We frequently hear of passage beds between the Chalk and Eocene, but the evidence is never produced which would show a gradual transition from one to the other. It has been said that in California such beds have been found; but Mr. Gabb in his extensive explorations did not observe them. The collection of fossil shells which he considered a newer Cretaceous formation, and designated as No. B is now in the collection of the Academy of Natural Sciences, and a careful revision of the species fails to enable us to detect one recognized form of the Cretaceous Period of California, or anywhere else. It is a peculiar group, however, unlike any other known. A glance at the large *Venericardia Hornii*, will strike any one accustomed to compare the Chalk and Eocene fossil shells as peculiarly indicating the Eocene. This statement of the distinct character of different formations, takes no account of those local mixtures of fossils which are easily traced to disturbances in the bed of the ocean.

13. *Diamonds in Australia.*—A letter from the Austrian Consul in Australia, to Mr. Hochstetter of Vienna, announces that the diamonds of Australia are remarkable for size as well as beauty. They vary in weight from half a carat to 150. One found on the property of the Consul, was of the first water, and weighed 30½ carats; and another, of 46 carats, was sold in London at 128,000 francs. The region especially abundant in diamonds is the frontier of the Orange River country, at Sikatlory.—*Les Mondes, Jan.* 13.

14. *The Æpyornis of Madagascar.*—MM. ALP. MILNE-EDWARDS and ALF. GRANDIDIER describe in Comptes Rendus, 11th Oct. 1869, certain curious anatomical peculiarities of the bones of the Æpyornis, and they observe "that it belongs to a group of shortwinged birds, but constitutes amongst them a type characterized by its massive forms, and by feet of a size difficult to conceive. It must be placed beside the dinornis and apteryx, although it is removed from them by important features of its organization, and by the pneumaticity of its thigh bones. The height of this bird was much less than J. Geoffroy St. Hilaire thought. Taking the length of its foot as a basis of calculation, the Madagascar bird scarcely exceeded two metres, which is the height of a large ostrich, while the *Dinornis giganteus* varied from two and a half to three metres. But if the Æpyornis is not, as was supposed, the

biggest of all these birds, it is the stoutest, the most massive, the most elephantine, if we may so express it."—*Student, Nov.* 1869.

15. *Preliminary Notice of the Lamellibranchiate Shells of the Upper Helderberg, Hamilton and Chemung Groups;* [*Preparatory Studies for the Palaeontology of New York*]; part 2; by JAMES HALL. 80 pp. 8vo. State Col. Nat. Hist. 1869.—This paper by Prof. Hall contains descriptions of several new genera and species, and revised references of other old species. The new genera are PALÆANEILO for *Nuculites constricta* Conrad, etc.; LIMOPTERA for *Lima macroptera* Conrad; MYTILARCA for *Megambonia ovata* Hall, etc.; PHOLADELLA for *Nuculites radiata* Conrad; CIMITARIA for *Cypricardites corrugata* Conrad, etc.; PHTHONIA for *Cypricardites sectifrons* Conrad; MODIOMOPHA for *Cypr. oblonga* Con. and *Modiola concentrica* Hall, etc.

III. ZOOLOGY.

1. *Molluscan Fauna of New Haven. A critical review of all the Marine, Fresh Water, and Land Mollusca of the region, with descriptions of many of the living animals and of two new species;* by GEO. H. PERKINS, Ph.D. From Proceedings of the Boston Society of Natural History, November and December, 1869.—The total number of species given in this catalogue is 162; of these 97 are Gasteropods (51 marine); 54 Lamellibranchs (40 marine). Of the 91 marine species 50 are said to occur north of Cape Cod; 13 in Labrador; 8 in Greenland; 8 in Europe; 51 extend to South Carolina and some of them farther; 37 occur in the Post Pliocene; 26 in the Pliocene; 19 in the Miocene. A list of 65 species recorded from Long I. Sound, but not yet found at New Haven, is given at the end. The two new species described and figured are *Nassa fretensis* (like *N. vibex*) and *Astarte lutea* (allied to *A. sulcata*). A new generic name, in errata *Tottenia* (by error *Tottenia*) is proposed for *Venus gemma* Totten, and *Crassivenus* instead of *Mercenaria* for *Venus mercenaria* Linn., the name, *mercenaria,* being objectionable because properly a *specific* name and an adjective. *Mytilus hamatus* Say is referred to *Brachydontes,* and *Pleurotoma brunnea* is proposed for *P. plicata* Adams.

The synonomy is far from complete, and although completeness could hardly be expected in a catalogue of this kind, yet it seems desirable to give, if any, such references as are necessary to explain the nomenclature adopted and the principal synonyms in all cases. But besides want of completeness there are many positive errors that are scarcely excusable even in a local list. In looking it over casually the following errors were noticed, besides others of less importance.

Thus "*Melantho decisa* Binney," should have H. & A. Adams as authority, and "*Vivipara decisa* Gill" in the synonymy, should be *M. decisa* Gill, instead of omitting the reference entirely (as in errata), for Prof. Gill was the first to correctly limit the two genera, as found in this country.

The "*Cytherea Sayii* Conrad," p. 147, should be *Cytherea Sayana* Conrad, Jour. Phil. Academy, vol. vii, p. 124, 1834; the reference to Gould, "p. 34," should be p. 84; "*Callista convexa* Say," should be *Cytherea convexa* Say; and finally the correct reference for "*Callista convexa*" is Adams' Gen., ii, p. 425. This species is really a *Callista*, unless we adopt Römer's subgenus, *Caryatis*, to which it also belongs. But Conrad's grounds for rejecting Say's name, *convexa*, seem to be insufficient,—at least I am unable to find another species of *Callista* with the same name. "*Mercenaria violacea* Stimpson," should be *M. violacea* Schumacher, "*Modiola modiolus* Linn," should read *M. modiolus* Turton, (*Mytilus modiolus* Linn.), and *M. barbatus* is no doubt a distinct Mediterranean species. "*Scapharca transversa* Say," should be *S. transversa* H. & A. Adams, (*Arca transversa* Say).

The following names, quoted as having Stimpson (Check List), Tryon, Conrad, etc., as authorities, are found in H. & A. Adams' Genera of Recent Mollusca, and some of them, perhaps, in earlier works:—*Amycla Gouldiana, A. dissimilis, Tritia trivittata, Cerithiopsis Emersonii, Lunatia heros, L. triseriata, Turbonilla interrupta, T. nivea, Melantho decisa, Bittium Greenii, Tectura testudinalis, Martesia cuneiformis, Xylotrya palmulata, Siliqua costata, Angulus tenera, A. polita, Peronea tenta, Macoma fusca, Brachydontes plicatula, Scapharca transversa.* V.

IV. ASTRONOMY.

1. *Elements of Asteroid* (109); by E. H. F. PETERS, of the Litchfield Observatory of Hamilton College. Communication dated Clinton, Oneida Co., N. Y., November 25, 1869.*—The following elements of asteroid (109) are computed from my observations of Oct. 9, 20 and 31.

Epoch 1869, Oct. 0·0 Berlin mean time.

Mean anomaly,	337° 1′ 3″·35.	
Longitude of perihelion,	55 53 48·04.	Mean Equ. 1870·0
Longitude of node,	4 51 45·43.	Mean Equ. 1870·0
Inclination of ecliptic,	7 56 56·55.	Mean Equ. 1870·0
Angle of eccentricity,	17 25 14·13.	
Mean daily motion,	809″·580.	
Logarithm of major semi-axis,	0·4278314.	

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On Force and Will*; by B. A. GOULD.—(We copy the following from an able address of Dr. Gould, at a meeting of the American Association last August, at Salem, Mass., as retiring President of the Association.)—

Scientists are now of accord that "force can neither be created nor destroyed," and that "the quantity of force in nature is just as eternal and unalterable as the quantity of matter." Its various

* This announcement was issued on a loose slip in connection with the January number of this Journal.

forms are eminently convertible, yet utterly indestructible. And to avoid that fruitful source of disagreement among the ablest men, which has arisen from the ambiguous signification of the word, we must adopt the meaning which is finding general acceptance, and define force as "that which is expended in producing or resisting motion;" thus clearly discriminating between force and its cause.

In his retiring address before this Association, last year, our honored ex-president Dr. Barnard presented an argument, so vigorous and clear that I see no room for an adequate rejoiner, in opposition to the doctrine which would extend the principle of the conservation of force to the phenomena of consciousness,—"a philosophy which at the present day is boldly taught in public schools of science, and which numbers among its disciples many very able men." He says, for instance:—

"Organic changes are physical effects, and may be received without hesitation as the representative equivalents of physical forces expended. But sensation, will, emotion, passion, thought, are in no conceivable sense physical."—[*Proc. Amer. Assoc., Chicago*, p. 89.]

"The philosophy, which makes thought a form of force, makes thought a mode of motion; converts the thinking being into a mechanical automaton, whose sensations, emotions, intellections, are mere vibrations produced in its material substance by the play of physical forces, and whose conscious existence must forever cease when the exhausted organism shall at length fail to respond to these external impulses."—[*Ibid*, p. 91.]

"Thought cannot be physical force, because it admits of no measure. * * A thing unsusceptible of measure cannot be a quantity, and a thing that is not even a quantity cannot be a force."—[*Ibid.* pp. 93, 4.]

Before the cogent reasoning carried out by President Barnard, of which the general tenor is indicated by these quotations, the view that force affords a middle term between the moral and the material worlds can be sustained as little as the pure materialism against which the argument was directed. But if we ascend a grade higher, and consider that which guides and compels force, as force guides matter, I am disposed to believe that the problem may be nearer to a solution. Yet I offer my views with hesitation, not unmindful of the great thinkers who have considered these exalted topics, and shrinking from the rebuke of presumption.

There is an elegant experiment, in which the tension of a spring is made to produce heat by percussion, thus developing the current from a thermo-electric battery, which by successive modifications of its force exhibits heat, chemical action, magnetic attraction, and finally bends another spring; the same original force successively appearing in all these various manifestations until it is reëstablished in its primitive form. In such an experiment the imperfections of the apparatus would of course entail some loss at each successive step, and thus preclude the practical recovery of an available force equal to that expended in the original flexure of the spring. Yet the fact is beyond question that such loss is due solely to the inadequacy of our implements for collecting and transmitting the force at each stage of the experiment; for the law of conservation teaches that it is in every instance converted into other form or forms without diminution. Could such an apparatus be constructed with theoretical perfection, it would represent an eternal circuit of force; and, like the frictionless pendulum in a vacuum, it would exhibit a perpetual motion, after the needful impulse had once been applied. The spring would oscillate forever, did no extraneous force oppose, whether the force producing its rebound were or were not transmitted through a chain of modifications.

In this inert apparatus no force whatever would have been embodied, yet qualities would have been implanted by design, which would compel an indestructible force, applied to it, to play the part of an unwilling Proteus. The influence seems unavoidable that force may be guided and controlled, compelled to exert itself in this or that shape, without the outlay of any other force for the purpose. If it be objected that it is an intrinsic law of force that it shall change its form in exerting itself, the case is in nowise altered by the expression of this truism. Our design has prescribed, and (extraneous force being absent) might indefinitely prescribe, the modes and directions in which that constant force should manifest itself.

Muscular force is directed, and in its vital action is usually controlled, by will. If we assume it to be coequal with the expenditure of tissue,* measurable alike by its transferred results and by the decomposition of this tissue, where and what is that power which lets loose or withholds this force, and whose action is attended by a conscious effort? It is the will,—a something which directs and controls force without expending it. Not only are thought and forms of consciousness not forces, if the reasoning already adduced be correct, but, although often moral incentives to the will, they are not even motive energies, in the sense in which I think we must concede the will to be such. It is true that the exercise of thought is followed by fatigue, yet it is not attended by a sense of effort, except in so far as it is directed by an exertion of the will. And although the former doubtless consumes tissue, have we any reason for believing that the exercise of will does the same, apart from that consumption which corresponds to the forces whose mode of action it prescribes?

Thus it would appear that the metamorphosis of force, though not "work done" in the mechanical sense, is the result of some definite mode of causation. What this causation is, and whether it is susceptible of measurement, are the next questions. In the same category with this agency, or energy, or influence, the vital principle would seem to belong,—directing forces while it neither expends nor consumes them. In the growth of organic beings, unstable combinations are formed, and organized structures are thence reared, in which, as Kant has so beautifully said, "all parts are mutually ends and means." If in such organic development force is consumed, disorganization without decomposition ought

* Even if it be also, to some extent, supplied by the disorganization of food not fully converted, the argument is not thereby affected.

to evolve it. Of the deposit of force in the unstable material of the tissues, I am not speaking, but of the vitality itself, which represents an energy requisite for the development and growth of organisms,—their dissolution being in turn attended by development of inferior forms of life, which suggest that this energy may have again been made available,—an energy too which is not "force," as this term has just now been defined.

No comparison can be drawn between vitality and those molecular forces which build the crystal. Crystaline forms arise when the molecular attractions enjoy the freest scope, and their construction must be attended by an evolution of force, which ought to be recognizable by physical tests, and which should also be measurable by an excess of their resistance to solution, over that of comparatively amorphous masses of the same material, in which equal weights present equal surfaces.

So, too, not only in that individuality which life confers and in the impossibility of insulating or transferring vitality, but also in its hereditary character and its apparent susceptibility of indefinite increase or diminution, the vital energy violates our fundamental conceptions of force, and demands a separate category, seeming to belong in the same with will. If will and life be forms of force, their total amount must be limited by the law of conservation. If, on the other hand, they are outside the realm of forces, we may more readily indulge the conviction to which experience would lead, that their freedom is unfettered by any restrictions within our knowledge,—each injoying an indefinite, though possibly a correlated scope in its own domain. The indestructibility of both matter and force implies a fixed coefficient of force for matter in equilibrium; but how great is the contrast offered in this respect by such energies as life and will!

Now if this reasoning be correct, we may have in this class of energies that middle term, so earnestly desired and so intensely needful, which unites the phenomena of matter with those of spirit, and forms the connecting link between science and religion; their harmonious conjunction affording the highest system of philosophy. It is this class of energies which, controlling the forces of matter, guides and governs their modifications and transformations. It is this, moreover, which, inseparable from mind, is exerted by all conscious organism. The mystic play of coequal, but to our senses, so dissimilar forces, and the equally recondite mutual action of the eye, the brain and the nerve, alike demand agencies transcending all our science, yet implicitly obeying physical laws. The highest manifestations of these agencies is in will; the highest agent is the Almighty. Thus the dictum of faith, that the universe exists only by virtue of the continued will of its Creator, represents a palpable scientific fact; and we may see that the pantheist, the materialist and the spiritualist (I will not be debarred from this noble word hy the associations of its misuse to-day) have been contemplating the same exalted truth from different aspects, with limited ranges of vision.

2. *On Auroral appearances and their connection with the phenomena of Terrestial Magnetism*; by Balfour Stewart, F.R.S. F.R.A.S.—Some years since, I ventured to suggest that auroral displays might be secondary currents due to small but rapid changes, caused by some unknown influence, in the magnetism of the earth. In developing this idea, the earth was compared to the core of a Ruhmkorff machine, and the moist upper strata of the earth, as well as the upper strata of the atmosphere, to secondary conductors, in which currents will take place whenever the magnetism of the earth changes from any cause. These views would appear to be confirmed by the very interesting records of earth-currents obtained by Mr. Airy at the Greenwich Observatory, in which it is found that during times of very great magnetic disturbance there are strong earth-currents alternating from positive to negative, the curves lying nearly equally on both sides of the zero.

A further development of this idea has lately occurred to me, in consequence of a remark of my friend Mr. Lockyer, that the zodiacal light may possibly be a terrestial phenomenon, and may therefore be somehow connected with the phenomena of terrestial magnetism. For not only will secondary currents be caused in a stationary conductor in presence of a magnetic core of variable power, but also in a conductor moving across the lines of force of a constant magnet. The question arises, have we on the earth such moving conductors? In answer to this, let us reflect what takes place at the equator. When once the anti-trades have reached the upper regions of the atmosphere, they will become conductors from their tenuity; and as they pass rapidly over the lines of the earth's magnetic force we may expect them to be the vehicles of an electric current, and possibly to be lit up as attenuated gases are when they conduct electricity. May not these form the zodiacal light?

Such moving currents will, of course, react on the magnetism of the earth. We may therefore suppose that somewhat sudden and violent changes are likely to take place in the earth's magnetism at those seasons at which the earth's great wind-currents change most rapidly. May not this account for the excess of disturbances at the equinoxes?

Besides the anti-trades there are also, no doubt, conviction-currents, caused by the daily progress of the sun, taking place in the upper regions of the earth's atmosphere. May not these also be vehicles of currents as they cross the lines of the earth's force, and account, to some extent at least, for the daily variations of terrestrial magnetism? and may not this be the reason of the likeness observed by Mr. Baxendell between the curves denoting the daily progress of the wind and those denoting the variations of the declination of the magnet? Such currents (in as far as they are electric conductors), taking place in the upper regions of the atmosphere, would not be felt by the earth-current wires at Greenwich, and I think Mr. Airy has noticed that this is the case. But the tidal wave represents a motion of a conductor on the earth's surface, with two periods in one lunar day. This motion cannot produce a very great secondary current; but may it not be sufficient to account for the lunar-diurnal magnetic variation, which is also very small?

Such a current taking place in a conductor electrically connected with the earth's upper surface ought to be felt by the Greenwich wires; and, if I am not mistaken, Dr. Airy has detected a current of this nature.

May we not also imagine that there are two varieties of aurora —one corresponding to stationary conductors under a very rapidly changing core, and the other to rapidly moving conductors under a constant core? And might not an aurora of the latter kind indicate the approach of a change of weather?

These remarks are thrown out in order to invite comment and criticism, and they will have served their purpose if they direct attention to the part that may be played by moving conductors in the phenomena of terestrial magnetism. It will be noticed that these remarks do not touch upon the mysterious connection believed to exist between magnetic disturbances and the frequency of solar spots.

P. S.—Since writing the above, Sir W. Thomson has called my attention to a paper by him in the Philosophical Magazine for December, 1851, in which it is suggested that moving conductors may play a part in the phenomena of terrestrial magnetism.—*Monthly Notice of the Royal Astronomical Society, Dec.* 10*th*, 1869.—*Phil. Mag.*, IV, xxxix, 159.

3. *The approach of violent storms announced by telegraph.*—In December, 1869, a memorial was presented to the House of Representatives, from Prof. J. A. Lapham, of Milwaukee, Wisc., calling the attention of Congress to the fearful loss of life and property occurring annually on our Great Lakes, and suggesting the possibility of doing something to prevent at least a portion of this loss in future. A bill was at once introduced by Hon. Halbert E. Paine, of Wisconsin, providing that the Secretary of War be authorized and required to provide for taking the necessary meteorological observations, at the military stations in the interior of the continent, and for giving notice on the northern lakes and Atlantic coast, by means of the electric telegraph, of the approach and force of storms. Letters were subsequently presented to the House of Representatives, from the Surgeon General of the U. S. Army, from Prof. Joseph Henry of the Smithsonian Institution, from Prof. Elias Loomis of Yale College, and from the chief Signal Officer of the U. S. Army, approving of the proposal of storm warnings, and suggesting some of the advantages which might be expected to result from them. The bill was passed in the House of Representatives, Feb. 2, and in the Senate Feb. 4, 1870. The following is a copy of the bill as adopted:—

"Be it resolved, etc., That the Secretary of War be and he hereby is authorized and required to provide for taking meteorological observations at the military stations in the interior of the continent, and at other points in the States and Territories of the United States, and for giving notice on the northern lakes and on the sea coast, by magnetic telegraph and marine signals, of the approach and force of storms."

If the system authorized by this act should be prosecuted earnestly and faithfully by the War Department, we anticipate that it will result not only in an important addition to our knowledge of the laws of storms, but will materially diminish the number and severity of marine disasters. Systems of this kind are already in operation in England, France, Holland, Italy, and other countries, and are producing important results. Our Atlantic seaboard is more favorably situated for receiving intelligence of approaching storms, than the western coast of Europe, since a majority of our violent storms have their origin on the land, and moving eastward may be telegraphed in advance to the principal commercial cities of the Atlantic coast.

4. *The Sars Fund.**—We are glad to find that the appeal made in our pages by Mr. Gwyn Jeffreys, on behalf of the family of the late Professor Sars of Christiania, is being warmly seconded in Paris by M. Alglave, the editor of the *Revue des Cours Scientifiques.* In the last number of the *Revue* Mr. Gwyn Jeffreys' article is reprinted *in extenso*, and an announcement made that subscriptions to the Sars Fund will be received at the office of that journal. But M. Alglave has not waited for the publication of his notice before beginning his good work ; he has already collected the sum of 2,026 francs (81*l.*), and publishes with the notice a first subscription-list containing the names of many of the most eminent naturalists in France. We have now the pleasure of giving in our advertising columns a list of the contributions already promised to Mr. Gwyn Jeffreys. Sars belonged to the best type of scientific men, the genuine lover of science, contented to work in obscurity without thought of honors or reward. His family have a special claim to help, inasmuch as the distress in which they are left is not due to neglect or extravagance on the part of the lamented Professor, but is solely attributable to his having devoted himself to studies, which, notwithstanding the most self-denying labors, did not enable him to make any provision for the future. Those of our readers who have visited Norway, who know the genuine unworldly ways of the Norwegians, and who have enjoyed the enthusiastic welcome so readily given to the English, have now a graceful opportunity of reciprocating the kindly feeling shown them by the countrymen of Sars.—*Nature, Feb.* 3.

5. *The Family of the late Prof. Michael Sars.*—In a notice of Prof. Sars, the editors state in the American Naturalist, Salem, Mass., of March, 1869, that in view of the fact that American Zoölogists are deeply indebted to Prof. Sars for the light he has thrown upon many of the lower animals, in the unrivalled investigation embodied in his publications, we feel it a duty to solicit aid for his family. Any sum, however small, which may be sent them will be welcomed, acknowledged and forwarded to his family through the Norwegian Minister.

* The death of this eminent zoologist of Norway, Mr. Sars, is mentioned in our January number, on page 144.

6. *Lighting Power for Buoys. Premium for the year* 1871 *offered by the Netherland Society for the Promotion of Industry.*—One of the greatest impediments to navigation is darkness in buoyed waters. If it were possible to develop a lighting power in the buoys, this difficulty would be greatly diminished, to the advantage of navigation.

The Society offers, therefore, her gold medal (representing a value of hundred fifty florins, Neth. Cy.) and an award of three hundred florins for the most practical means of investing buoys with a lighting power, for service at night.

Conditions.—1. The answers must bear a distinctive mark, epigram or motto, and be accompanied by a sealed envelope, containing the competitor's name, and bearing outside the same mark, epigram or motto as above.

2. The competitors are requested to communicate an intermediate address, in case of eventual correspondence.

3. The answers and any other accompanying writing must not be in the competitor's own hand.

4. The successful answer becomes the property of the Society, which reserves to itself the right of publication.

5. The Society takes no responsibility for eventual damage to models or instruments, illustrative of the answers, and reserves to itself the right of not returning them to the competitors.

6. Answers are requested post paid before the 30th of September, 1871, to the address of the General Secretary and Treasurer of the Society, F. W. Van Eeden, Haarlem, the Netherlands.

7. *Academy of Sciences, Paris.*—Mr. A. DesCloizeaux, the distinguished Crystallographer and Mineralogist, whose optical researches in connection with crystals have done so much to advance the science of mineralogy, has been elected a member of the Academy in place of the late Mr. d'Archiac; and Professor Mayer, the eminent physicist, in place of the late Professor Matteucci.

OBITUARY.

Rev. George Jones, U. S. N.—On the 22d of January, 1870, at the Naval Asylum, in Philadelphia, died Rev. George Jones, long connected with the United States Navy as a Professor and a Chaplain; but better known in science for his important contributions to our knowledge of the zodiacal light. His labors in this department fill the third volume of the U. S. Japan Expedition, embracing observations from April 2d, 1853, to April 23d, 1855, made chiefly on board the U. S. steam frigate Mississippi, and are included on 340 charts, followed by Cassini's observations (10 in number) in 1685 and 1687. In his Introduction to this volume, Mr. Jones expresses his intention to spend a year at Quito, Ecuador, with a view to compare and extend his zodiacal light observations from that equatorial and lofty position. This purpose he executed in the year 1856, adding greatly to the fullness of his researches upon this wonderful phenomenon. A summary, by himself, of his observations in Ecuador was published, with three plates, in vol. xxiv of this Journal, 1857, p. 374; but the great mass of data then collected remain still unpublished. Mr Jones was a patient and most conscientious observer, and his contributions in this department of astronomy must ever form an important feature in any discussion of the phenomenon, notwithstanding Prof. Piazzi Smyth's most extraordinary and flippant assertion that Mr. Jones had never seen the zodiacal light at all!

Mr. Jones was the author of Sketches of Naval Life, 2 vols., New Haven, 1829, and Excursions to Cairo, Jerusalem, &c., one volume, New York, 1836, besides other works of a religious character. It was largely owing to the asssiduity and patient tact of Mr. Jones that the U. S. Naval Academy was créated against the instructive prejudices of most of the older naval commanders, a labor for which he never sought credit or fame, but not the less worthy of being remembered and recorded to his lasting honor. Mr. Jones graduated at Yale College in 1823, and was a tutor there from 1828 to 1830.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Transactions of the Chicago Academy of Science*, Vol. I, Part II, 1869. Large 8vo, with steel engraving and fourteen plates.—The first volume of Transactions of the Chicago Academy, now completed, does great honor to the society and to the enlightened liberality of those gentlemen who have furnished the means of illustrating it with so many beautiful plates. The first article is a biographical sketch of Dr. Robert Kennicott, the late Director of the Academy, with portrait and interesting extracts from the diaries, written during his well-known arctic explorations. The article on the Antiquity of Man in North America, by Dr. J. W. Foster, is of special interest at this time, and contains a summary of all the evidences hitherto obtained upon the subject. It is illustrated by six plates. The "List of the birds of Alaska, with biographical notes," by Wm. H. Dall and H. M. Bannister, and Prof. Spencer F. Baird's descriptive list of the "Additions to the Bird-Fauna of North America made by the Scientific Corps of the Russo-American Telegraph Expedition," illustrated by excellent colored plates of all the species, are very valuable contributions to American Ornithology. In the former 212 species of Alaska birds are enumerated, with valuable notes on their habits and distribution. Mr. S. H. Scudder enumerates 46 species of butterflies collected by J. A. Allen in Iowa, several of which are described as new. V.

2. *Guide to the Study of Insects;* by A. S. PACKARD, Jr., M. D. 8vo, 702 pages, with eleven plates and 650 wood-cuts. Salem, Mass., 1869. Naturalist's Book Agency.—This excellent work, published in ten numbers, is now completed. It is really an admirable manual of entomology by an author thoroughly versed in the science, and who is at the same time an original investigator. On this account it has a much higher character than a mere compilation, which is too seldom the case with scientific manuals and text books. The work is well illustrated, and followed by a

glossary and full index. The structure and classification of insects are fully discussed, as far as the families and the prominent genera and species in each family are described. It includes also full directions for collecting and preserving insects, and various other useful information on transformations, habits, distribution, geological history, etc., as well as descriptions of new species and genera in some of the orders. It embraces the *Arachnida* and *Myriapoda* as well as the Hexapod insects, which is quite unusual in treatises on entomology. V.

3. *Theory of Existence:* Part I. Devoted to the enunciation of the laws which determine the motions that result from the collision of ponderable bodies; by ELIAS DEXTER. 156 pp. 8vo, with 5 plates. 1869. New York. (Edward Dexter, 564 Broadway).—The laws enunciated in this singular book, beginning with the first paragraph defining velocity, are, with few exceptions, entirely at variance with the received principles of mechanics, so that in the concluding sections, which are devoted to the refutation of Newton's Laws of Motion, the author finds it easy to show by reference to the earlier part of his own book, that the views of Newton are quite erroneous. The age is prolific in such waste efforts by the "advance men" of the times.

4. *A Practical Treatise on Metallurgy adapted from the last London edition of Professor Kerl's Metallurgy.* Vol. iii; *Steel, Fuel, Supplement;* illustrated with 145 wood engravings; by WILLIAM CROOKES, F.R.S., and ERNST RÖHRIG, PH.D., M.E. 820 pp. 8vo. New York, 1870. (John Wiley & Son.)—This volume is a most valuable addition to our previous literature upon the important subjects of which it treats, and it is not too much to say that the metallurgical student will seek in vain, elsewhere, for such a comprehensive summary of recent progress in this department of knowledge. The arrangement of the materials is excellent and the subjects are discussed with all desirable fulness; thus the Bessemer steel process covers 80 pages; while proper notice is taken of all other methods, even to the Ellershausen process, Bessemer's new system of high pressure, hot blast furnaces, and Siemen's process of producing steel direct from the ores. The table of contents covers 21 pages, and exhibits clearly the great range of interesting topics which fills the volume. Full references to original memoirs in all languages bearing on steel and fuel add value to the work. This is altogether the most important contribution of the three volumes, of which it is the last as well as best.

5. *Lithology of the Seas of the Old World;* by M. DELESSE.—Of this work by M. Delesse we have seen only the chart. In the work the author, as is stated in a resumé received from him, takes up the lakes and seas of the old world in succession, describes their several features, or peculiarities, the character of the shores and bottom, and the relative amount of life distributed over the several parts. The subject is one of great interest and if thoroughly carried out, would make a very important contribution to the sciences of geology and physical geography. The map is an exceedingly beautiful example of engraving and coloring.

6. "*Nature.*"—This scientific weekly, published by MacMillan & Co., London,* the first number of which was noticed in our last volume (p. 451) sustains well the promises made in its prospectus. It is popular in the character of many of its articles, and well furnished with the scientific news of the day, besides reviews of new works. It is not in any proper sense a special organ of Darwinism, which the first number seemed to suggest. Illustrations are often given when the subjects require it. The number for December contains a map of a part of Africa, presenting a view of the recent discoveries and Livingstone's route, which would be convenient to readers of Livingstone's letter in the last number of this Journal, and that for Jan. 20th has a map of the polar regions, and the routes of the recent exploring parties in that direction.

7. *Paris Universal Exposition*, 1867; *Reports of the United States Commissioners.*—We have already made mention of some of the more important of these Reports, and have offered the titles of all which have appeared up to this time, and copies of which have reached us by the courtesy of the editor, Professor Wm. P. Blake, who has carried these documents through the press in a manner creditable to the occasion.

Machinery and Processes of the Industrial Arts, and Apparatus of the Exact Sciences; by Frederick A. P. Barnard, LL.D. pp. 669. Plates.

Examination of the Telegraphic Apparatus, and the Processes in Telegraphy; by Samuel F. B. Morse, LL.D. pp. 166. Plates.

The Production of Iron and Steel in its Economic and Social Relations; by Abram S. Hewitt. pp. 183. Plates.

Report upon the Precious Metals: being statistical notices of the principal gold and silver-producing regions of the world, represented at the Paris Universal Exposition; by William P. Blake. pp. 669.

The Progress and Condition of Industrial Chemistry; by J. Lawrence Smith. pp. 146. Plates.

General Survey of the Exhibition, with a Report on the Character and Condition of the United States Section. pp. 324.

The Manufacture of Beet Sugar and Alcohol, and the Cultivation of Sugar Beet; by Henry F. Q. D'Aligny. pp. 90. Plates.

Report on Corals; by Samuel B. Ruggles and G. S. Hazard. pp. 26.

Report upon Cotton; by E. R. Mudge, with a Supplemental Report by B. F. Nourse. pp. 115.

Report upon Buildings, Building Materials and Methods of Building; by James H. Bowen. pp. 96.

Report upon Wool and Manufacturers of Wool; by E. R. Mudge, assisted by John L. Hayes. pp. 143.

Preparation of Food. Pressed or Agglomerated food. Culture and Products of the Vine. Photographs and Photographic Apparatus. Outline of the History of the Atlantic Cable. School Houses and the Means of Promoting Popular Education.

* The subscription price for "Nature" is fourpence; or for America, as announced by the house of Macmillan & Co., 63 Bleeker st., New York, 12 cents a number, and $5.00 a year.

Report on Silk and Silk Manufacturers; by ELIOT C. COWDIN. pp. 51.

Report on Instruments and Apparatus of Medical Surgery and Hygiene; by THOMAS W. EVANS, M.D. pp. 70.

Report on the Fine Arts, and the Fine Arts applied to the Useful Arts; by FRANK LESLIE, S. F. B. MORSE and THOMAS W. EVANS. pp. 43. Plates.

Report on Béton-Coignet: its fabrication and uses. Report on asphalt and bitumen, and their application to streets, roads, buildings, &c.; by ARTHUR BECKWITH. pp. 21, and 31 plates.

Report upon Steam Engineering, as illustrated by the Paris Universal Exposition, 1867; by WILLIAM S. AUCHINCLOSS. pp. 72.

Report on the Munitions of War; by CHAS. B. NORTON and W. J. VALENTINE. pp. 213.

In addition to the foregoing reports, there are yet to come others on the following subjects: *Mining; Clothing; Engineering Works; Education; The history of the Organization and Progress of the Exhibition;* including *titles, list of reports, authors, tables of weights and measures, etc.* The whole series will be bound in six volumes of some 600–700 pages each.

PROCEEDINGS AMERICAN PHILOSOPHICAL SOC., Vol. XI.—p. 119, Prodromus of a study of the Fresh Water Algæ of Eastern North America; *H. C. Wood, Jr.*—p. 147, Seventh Contribution to the Herpetology of Tropical America; *E. D. Cope.*—p. 171, Synopsis of the Extinct Mammalia of the Cave Formations in the United States, with observations on some Myriapoda found in and near the same; *E. D. Cope.*—p. 195, Some Suggestions on the maintaining forces of Cosmical motion; *W. H. Lowrie.*—p. 202, Tidal Rain-fall; *P. E. Chase.*—p. 204, Abstract of Results of Measurements and Examinations of the Photographs of the Total Eclipse of Aug. 7, 1869; *A. Mayer.*—p. 209, Profile of Recent Flood in the Schuylkill; *J. C. Cresson.*—p. 213, Indian Relics from New Jersey; *G. B. Wood.*—p. 215, Comets and Meteors; *D. Kirkwood.*—p. 220, Search for a Normal Cause of the Recession of Cosmical Nodes; *W. H. Lowrie.*—226, Medical Activity of the Hemp Plant as grown in North America; *H. C. Wood, Jr.*—p. 233, Silver Coins; *W. E. DuBois.*—p. 235, Coal Borings in the Wilkesbarre Basin; *P. W. Sheafer.*—p. 237, Supposed Laurentian Fossil; *R. J. Roscoe.*—p. 237, Experiment on the Revival of Peach Trees; *G. B. Wood.*—p. 240, Second Addition to the History of the Fishes of the Cretaceous of the United States; *E. D. Cope.*

PROCEEDINGS BOSTON SOC. NAT. HIST., Vol. XIII.—p. 139, Molluscan Fauna of New Haven, part II, Acephala and Bryozoa; *G. H. Perkins.*—p. 167, Occurrence of the Remains of *Tarandus rangifer* Gray, at Big Bone Lick, Kentucky; *N. S. Shaler.*—p. 169, American Lepidoptera, II, Phalænidæ; *C. S. Minot.*—p. 172. Native Carbonate of Magnesia from California; *C. T. Jackson.*—p. 172, Remarks on the Relations of the Rocks in the vicinity of Boston; *N. S. Shaler.*—p. 178, Notes on the Mammals of Iowa; *J. A. Allen.*

ANNALS LYC. NAT. HIST. OF NEW YORK. Vol. IX, No. 8.—p. 237, Catalogue of Birds from Puna Island, Gulf of Guayaquil, in the Museum of the Smithsonian Institution, collected by J. F. Reeve; *G. N. Lawrence.* (Continued.)—p. 238, Additional Notes on the Geographical Distribution of Land Shells in the West Indies; *T. Bland.*—p. 242, Note on Lovén's Article on "Leskia mirabilis, Gray;" *A. Agassiz.*—p. 246, Observations on a Collection of Chalchihuitls from Central America; *E. G. Squier.*—p. 265, Characters of some New South American Birds, with Notes on other rare or little known Species; *G. N. Lawrence.*—p. 276, On the names applied to Pisidium, a genus of Corbiculadæ; *T. Prime.*—p. 280, List of the Species of Mollusca found in the vicinity of North Conway, New Hampshire; *T. Prime.*

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. XXIX.—*On a method of producing, by the Electric spark, figures similar to those of Lichtenberg;* by Eli W. Blake, Jr.

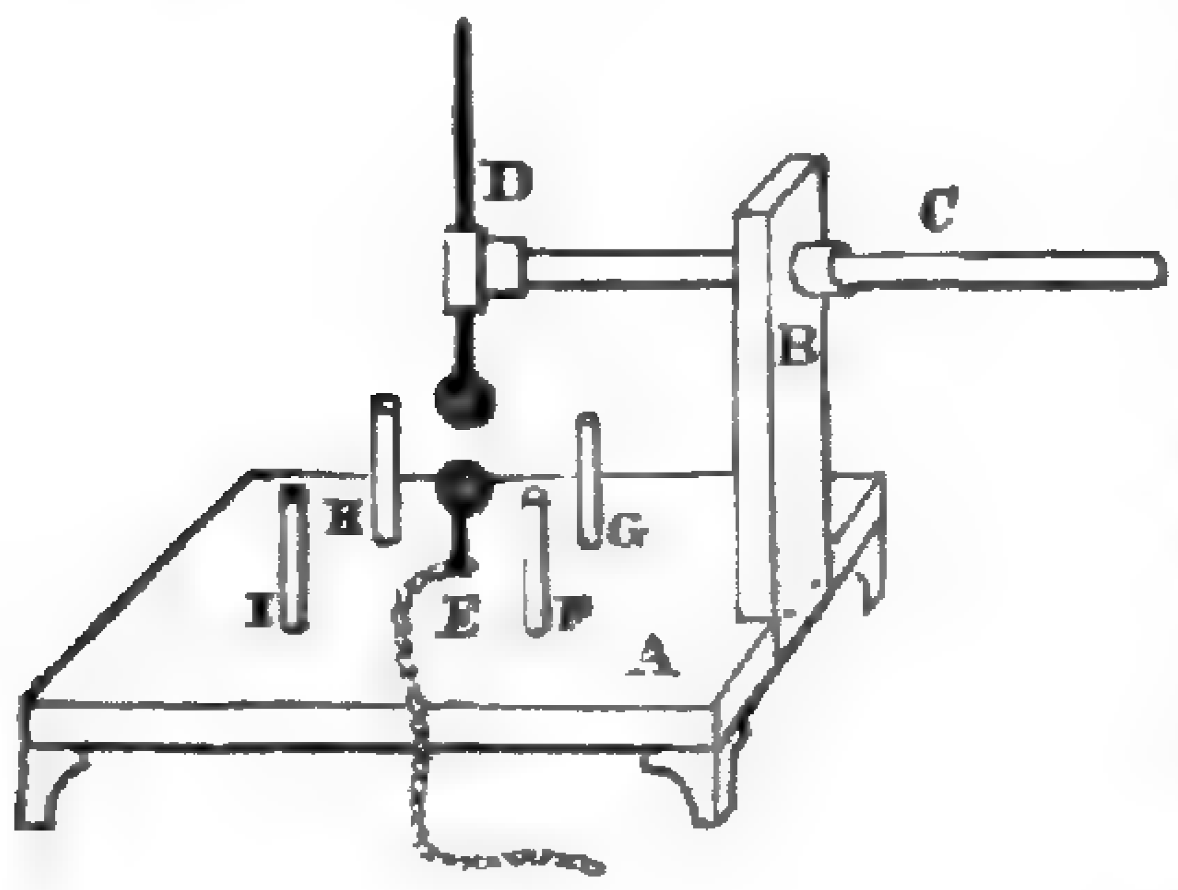
Lichtenberg's figures, discovered in 1777, are a result of the attraction of an electrified surface for light particles of electrified or unelectrified dust. Prof. Rood has shown that figures entirely similar in form are produced, when the spark is allowed to fall on the sensitized collodion film of an ordinary photographic plate, and the latent image is developed in the usual way.

The method I have to describe consists in throwing the discharge upon the surface of a fusible non-conducting body. If the body be near its fusing point the figure appears at once,—if cold, a latent image exists which may be "developed" by heat.

The non-conducting surface is prepared by coating a plate of metal with an even film of pitch. Pieces of sheet-tin, 3 inches square, coated with films of pitch of a thickness varying between 0·01 and 0·02 in., were used in most of my experiments. The pitch was the ordinary commercial article, freed from sand, fragments of bark, &c., by being melted and strained through a muslin bag. Shellac, rosin, Burgundy-pitch, bees-wax and Canada balsam were in turn tried as substitutes for pitch, but with unsatisfactory results.

A simple apparatus for holding the plate during the discharge, is represented in fig. 1. The upright B supports the insulating arm C,—a rod of glass, which may be turned in its bearing, but is prevented from moving longitudinally. The arm C holds the wire D. This wire slides up and down with considerable friction so as to retain any position given to it. It is graduated to tenths of an inch, and terminates, at one end, in a sharp point—at the other, in a metal ball ½ inch in diameter. Directly beneath D is a similar wire, E, passing through the board A, and held by friction. Around E, at the corners of a three-inch square, are disposed four insulating posts, upon which the prepared plate is laid.

1.



In experimenting, merely to obtain the figures, the arm C is turned so as to bring the wire D into a horizontal position,—the prepared plate is laid upon the insulating posts (for the + figure with the pitch side uppermost). The wire E is made to touch the plate below, and is put in connection with the earth. D is then made vertical, and is adjusted to the desired striking distance. An insulated connection being made between D and a charged prime conductor, the + spark passes over to the pitch. The − figure is obtained when the pitch side is beneath, D in contact with the plate, and E depressed to the proper striking distance. The discharge having taken place, D is again made horizontal, and the plate may be removed for development. This process consists in gradually warming the plate over a lamp. The metal side must be presented to the lamp, as the slightest touch of a flame on the excited pitch instantly dissipates the electricity. At a certain temperature, (in my experiments about 60° C.,) the figure will begin to appear, and in a few seconds the development is completed. The plate being now allowed to cool, the figure becomes permanent. If the plate be overheated the figure is destroyed. It may be instantly obliterated by exposure for a second to the naked flame, and the plate may then be used again. The proper temperature for development is some degrees below the real fusing point of the pitch used.

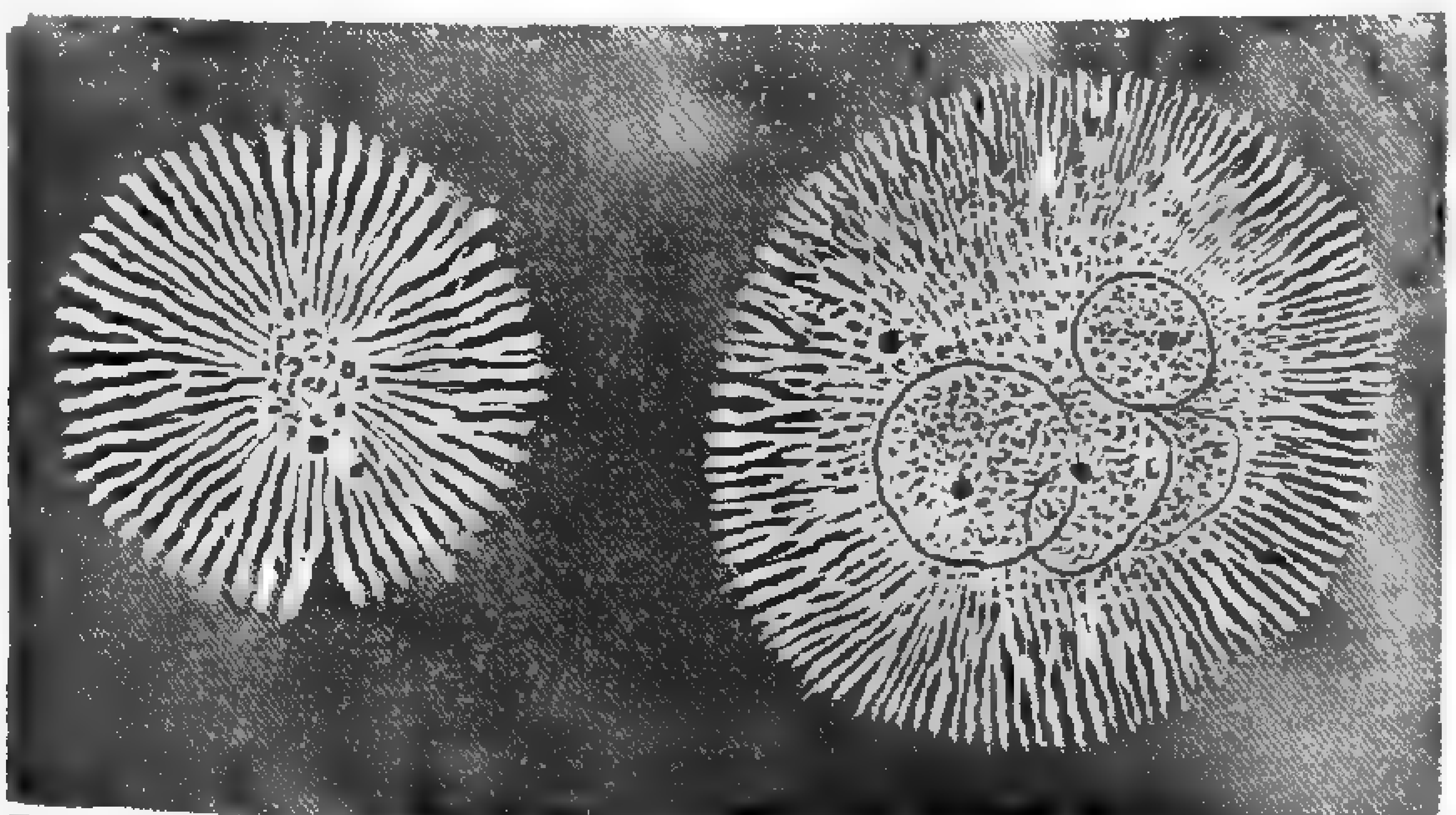
The figures, obtained as described, are formed by depressions and elevations of the excited surface. The depressions would appear to be the true figures, as they correspond exactly in form to those obtained by Lichtenberg. The plate may be dusted before development; the form thus revealed will be reproduced in depressions upon warming. The depth and sharpness of these depressions vary with the quantity of electricity, and the thickness of the film of pitch. The thinner the film, the sharper the lines. The exact depth of the depressions below the general level is very difficult to measure, owing to the elevations produced. In films of 0·015 in. thickness, the deepest lines are about 0·005.

When cold, the pitch is sufficiently hard to allow of several impressions being taken from it in printing ink. The wood-cuts given below were made from such impressions, transferred to a block, and then engraved. The white portions therefore represent depressions. The "ground," representing the level surface of the pitch, was lightened by ruling, so as to bring out the exterior ring of the negative figure.

Frictional Electricity.

Discharge from balls.—The positive spark produces the figure of a star (2 and 3). Sometimes the rays diverge almost from the center, but generally the central portion is broken up into a confusion of minute elevations, which in the cuts show as dots. The rings sometimes seen in this central portion resemble the negative figures, and suggest the idea of oscillations in the discharge.

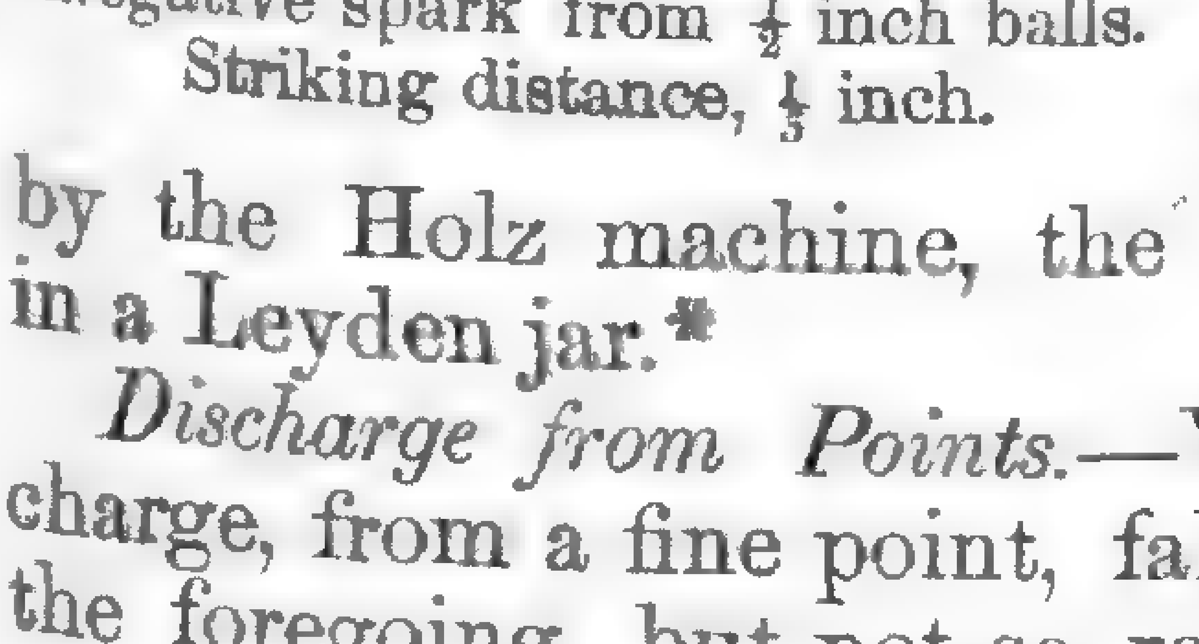
2. 3.



Positive spark from ½ inch balls. Striking distance, ⅕ inch.

The negative spark gives the figure shown in (4). An elevated ring forms the outer boundary; inside of this comes a deeply depressed circle surrounding a circular disc, whose surface is so irregular that I have not been able to determine whether it is, on the whole, above or below the general level of the pitch film. Perfectly similar figures were obtained by means of the electricity developed by the Holz machine, the electophorus and that accumulated in a Leyden jar.*

4. 5.



Negative spark from ½ inch balls. Striking distance, ⅕ inch.

Discharge from Points.—When a single, instantaneous discharge, from a fine point, falls upon the film, figures similar to the foregoing, but not so regular, are obtained. If, however,

* In experimenting with a well charged Leyden jar, if the electrodes D and E (fig. 1) are connected with the coatings of the jar, the discharge is so violent as to perforate the film of pitch. Surrounding the minute perforation is a circular crack. Generally the circular fragment thus set free is thrown out, and in the center of the bright spot of tin exposed, a minute dot is seen. On examination by a magnifier, it will be seen that the tin is fused at this point. That this is not a thermo-electric action of the tin, and iron, is proved by the fact that the fusion takes place whether the discharge is positive or negative. In using such a jar for the production of figures the electrode E should be removed and the spark thrown on the insulated plate.

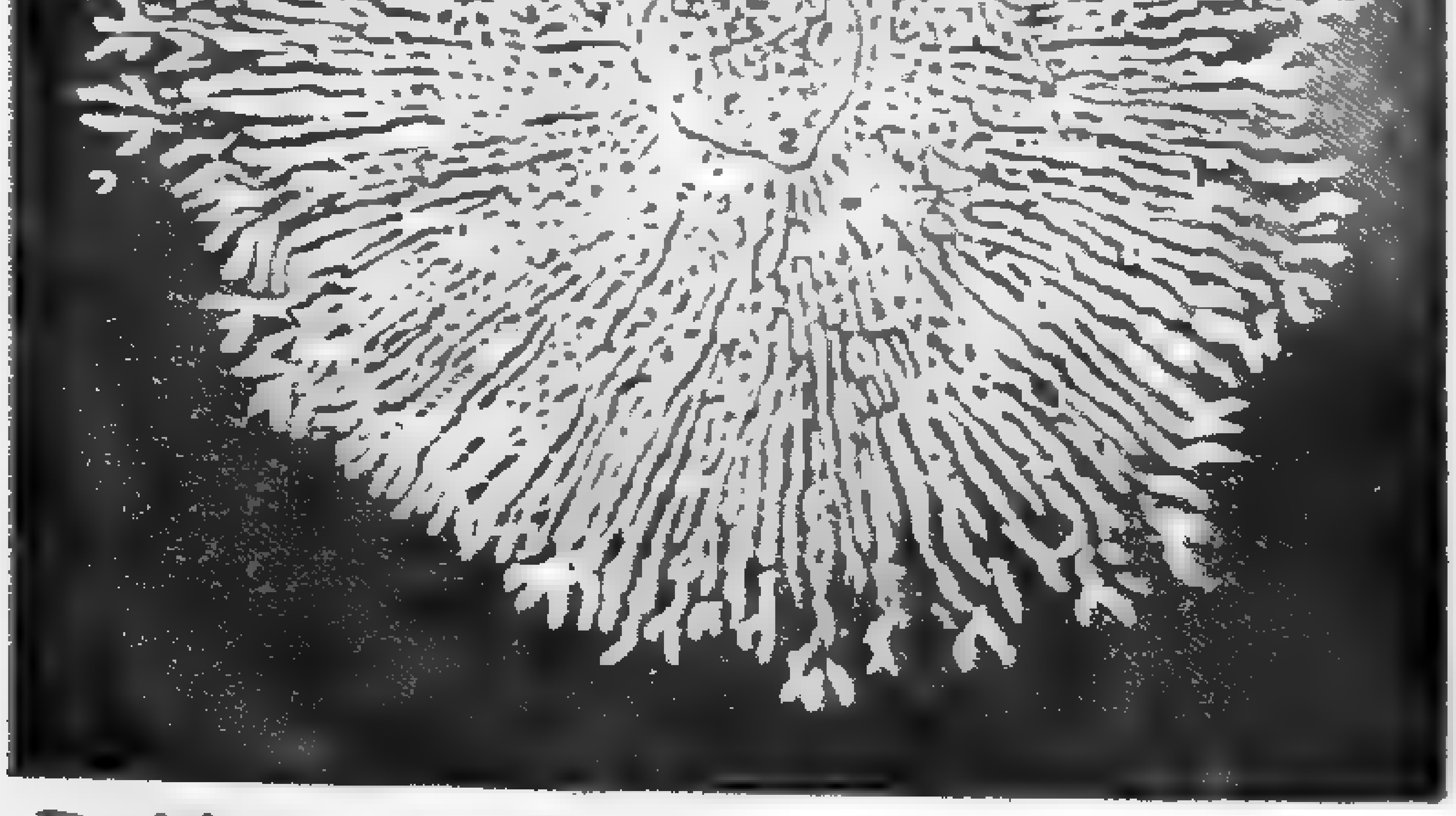
the discharge be of negative electricity, and be continued for a short time, (e. g. during a quarter-revolution of a 20-inch plate of the ordinary frictional machine,) the first effect of developing is to bring out a *star*, which might readily be mistaken for the positive figure. Inspection shows however that the rays are not *depressed*, but *elevated*. The rays are generally more or less curved, and resemble the projection on a plane of the meridians of a hemisphere. The plane of projection is different in almost every figure. Precisely such a star occurs in the figure, given below, of the negative spark from the induction coil.

If the discharge from the point be continued for some seconds, the plate, on developing, shows an infinity of minute circular depressions with no characteristic distinction between +E and −E. In developing these plates, especially those charged with −E, vivid sparks may be seen to rise from the pitch, visible even in broad day-light.

Figures produced by the Induction Coil.

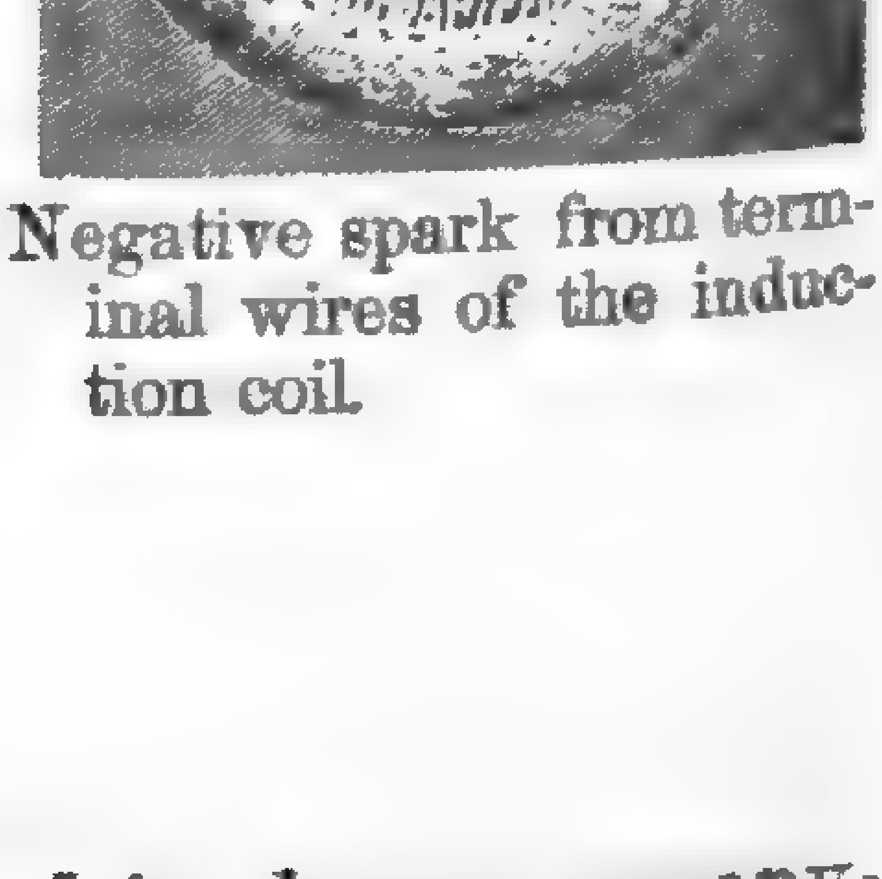
The coil used in these experiments was made at Ruhmkorff's establishment in Paris. It is capable of giving an 8-inch spark, but, by reducing the primary current, the striking distance was brought down to $\frac{1}{4}$ inch. A single Bunsen's cell was used,—the carbon being withdrawn so as barely to touch the nitric acid.

6.



Positive spark from terminal wires of the induction coil.

7.



Negative spark from terminal wires of the induction coil.

The positive figure obtained is represented in the accompanying cut (6). Except its larger size, as compared with frictional electricity of the same striking distance, there is nothing noticeable in it.

The corresponding negative figure is seen in (7). The central star with curved rays, referred to above, is surrounded by a deeply depressed circle, which is bounded by a slightly elevated ring. The terminal wires evidently acted here as points, for the *star* was not obtained when the discharge took place from balls.

Simultaneous production of the Positive and Negative Figures.—For this, a plate coated with pitch on both sides is required. The electrodes D and E (fig. 1) are adjusted at equal distances from the upper and lower surface of the plate. Upon connecting D with the prime-conductor the positive spark falls upon the upper, while the negative spark leaps up to the lower surface of the plate. Development by the lamp, without obliteration of one of the figures, being impossible, the plate may be heated in an air-bath to about 60°–65° C. It is more convenient, however, to throw the discharge upon the plate when warm, the figures then appear at once. By using plates of glass, or mica, instead of metal, the relative size of the figures is at once seen. The negative figure is considerably less in diameter than the positive.* This fact explains why, when +E and −E are thrown on the same spot, they do not neutralize each other and the resulting figure is a combination of the two.

An interesting fact, in connection with this subject, is the length of time that may elapse between the reception of the spark by the plates, and the development of the figure. Several plates were charged in immediate succession, and developed, one by one, at intervals of two hours. The last, developed after twelve hours, showed hardly any loss in depth or sharpness, although the weather was damp and unfavorable. Of another series, the last, developed after *seven days*, still came out distinctly.

A charged plate may be breathed upon, and the condensed moisture be allowed to evaporate, several times, without apparently injuring the latent image. To test the discharging power of a point, the following experiment was made. One end of a copper wire was filed to a sharp point; the other end was then soldered to a metal plate. This plate had two intersecting lines scratched on its surface, and was coated with pitch. The spark having been made to fall on the spot marked out by the intersection of the lines, (visible through the pitch), the copper wire was bent over so that its point was directly over the center of the latent image and very near it. After 12 hours, this plate, on developing, gave a good figure.

From the manner in which the figures are produced, it would appear that they are due to the attractions and repulsions of the

* Riess has shown (Pogg. Ann., B. lxix), that the areas of the surfaces occupied by +E and −E of equal quantity, and developed under the same conditions, are as 7 : 1.

excited surface.* This seems proved beyond doubt by the identity of the Lichtenberg figures, with the depression figures produced on developing. No chemical change of the pitch could enable it to attract dust.

As the point of temperature at which developement begins is considerably below the true fusing point of the pitch, the *work* performed by the electricity is no inconsiderable quantity. Does the electricity disappear in performing this work? The fact that the depression of the surface stops at a certain point, while the attraction for the opposite E on the metal plate should be constantly growing stronger, seems to point to an affirmative answer. As pitch, however, is said to become a conductor when fused, it may be that the two electricities are gradually transmitted and neutralize each other. Experiments have been undertaken in the hope of obtaining a decisive answer to this question, but as yet with no result worthy of publication.

Cornell Univ., Ithaca, N. Y., Feb. 6th, 1870.

ART. XXX.—*On the Magnesium and Electric Lights, as applied to Photo-Micrography;* by Brevet Lt.-Col. J. J. WOODWARD, Assistant Surgeon, U. S. Army. Report to Brevet Major General J. K. Barnes, Surgeon General of the United States Army, dated Army Medical Museum, Microscopical Section, January 4, 1870.†

I HAVE the honor to inform you that, on the 25th of October last, I began to conduct in person a series of experiments, intended to devise means for escaping certain difficulties which had hitherto prevented the successful preparation of Photo-micrographs of specimens, selected from the valuable and daily increasing series of permanently mounted microscopic sections of normal and pathological tissues, which form so interesting a portion of the treasures of the Museum. In these experiments I used the sun as a source of illumination, and, following the process which I have described in full elsewhere,‡ I had no difficulty in arranging a method, by the aid of which this class of objects could be photographed quite as successfully and readily as the diatoms and other test objects which had previously been so satisfactorily reproduced in this section of the Museum. I shall take occasion in the course of a few days to lay before you

* The laws of attraction and repulsion, for both positive and negative electricity being the same, it is not clear to what cause the difference of the figures is to be attributed.

† Communicated for this Journal by Lieut. Col. J. J. Woodward.

‡ Circular No. 6, War Department, Surgeon General's Office, Nov. 1, 1865, page 148, *et. seq.*; this Journal, II, vol. xlii, Sept., 1866.

prints of some of the tissue-preparations thus reproduced. At present it is my desire to call your attention to certain important observations which I had the good fortune to make, while my experiments were in progress, and which it appears to me cannot fail to be of interest and service to all microscopists.

During the last week of October and the first two weeks of November, I relied wholly on the sun as the source of illumination for producing negatives. In this period, during which I had but two perfectly cloudless working days, and several fractional days on which my work was continually interrupted by passing clouds, I had ample opportunity to convince myself that the uncertainty of the weather was a most serious hindrance to the preparation of successful photographs of microscopic objects, and I ceased to wonder that European microscopists, who are exposed to a climate even more variable than our own, have not yet succeeded in placing the art of Photomicrography upon such a basis, as to make a convenient and habitual auxiliary in all microscopical investigations. This desirable end I believe I have attained; but it has been by resorting to artificial lights and thus making the success of the process wholly independent of the weather.

On the 12th of November I commenced a series of experiments with artificial lights which were most fortunately crowned with success, both the magnesium and the electric lights proving adequate sources of illumination for the production of Photo-micrographs even with the highest powers.

For the production of the electric light I used a Duboscq's lamp, set in motion by a battery of fifty small Groves' elements. I found that, with this source of light, photographs could be successfully taken with any power with which pictures can be taken by sunlight; and I was delighted to find, as I had anticipated, that the very exaggeration of light and shadow which has prevented the electric light from being generally adopted as a source of illumination in the preparation of photographs of the size of the object, or smaller, proved of immense advantage in the reproduction of the feeble microscopical images of highly magnified objects, and that the pictures were hence clearer and better defined than any photographs of similar objects I had hitherto seen produced by sunlight. I found also that the electric light was so much more manageable than sunlight as a source of microscopic illumination, that I could readily arrange it to produce negatives with much shorter exposures than are indispensable with the sun.

The magnesium light shared these qualities to a high degree, but I found that its best work was done when the object was not to be magnified more than a thousand diameters, and that there were certain limitations to its use on test objects which will be referred to in the sequel.

With one or the other of these artificial lights as a source of illumination, I have prepared a considerable number of negatives of interesting microscopical objects, of which a few are appended to this report by way of illustration, while the others will be laid before you in future reports on special subjects.

The magnesium and electric lights are mentioned as possible sources of illumination for the production of Photo-micrographs by Dr. Lionel Beale, in the 4th edition of his "How to Work with the Microscope," page 275. I am not aware, however, that any one has made successful negatives with high powers with either of these lights prior to the experiments here recorded. There are in the Museum a few photographs with low powers taken with the magnesium light by Dr. C. F. Crehore, of Boston, Mass., who kindly presented them August 3, 1866. Negative No. 90, old Microscopical Series, Army Medical Museum, represents a few villi from the small intestine of a mouse, photographed by the electric light with a $\frac{4}{10}$th objective of Wales arranged to magnify 84 diameters. The electric light was produced by forty Bunsen's cells, and as I had no electric lamp at the time, I held the carbon points in two retort holders and managed as best I could, during the exposure, the uncertain light thus produced. I know of no other Photo-micrographs than the above to have been actually made by the electric or the magnesium lights; certainly if any have been, they have not been sufficiently successful for their authors to be willing to give them any degree of publicity. I have no hesitation, therefore, in claiming for the Museum and for myself the credit of having demonstrated the serviceable character of these lights as sources of illumination for the preparation of negatives with high powers, and of having devised a simple method which brings their use within the reach of every microscopist.

I propose now to sketch briefly the process by which negatives of microscopic objects can be conveniently produced with these artificial lights.

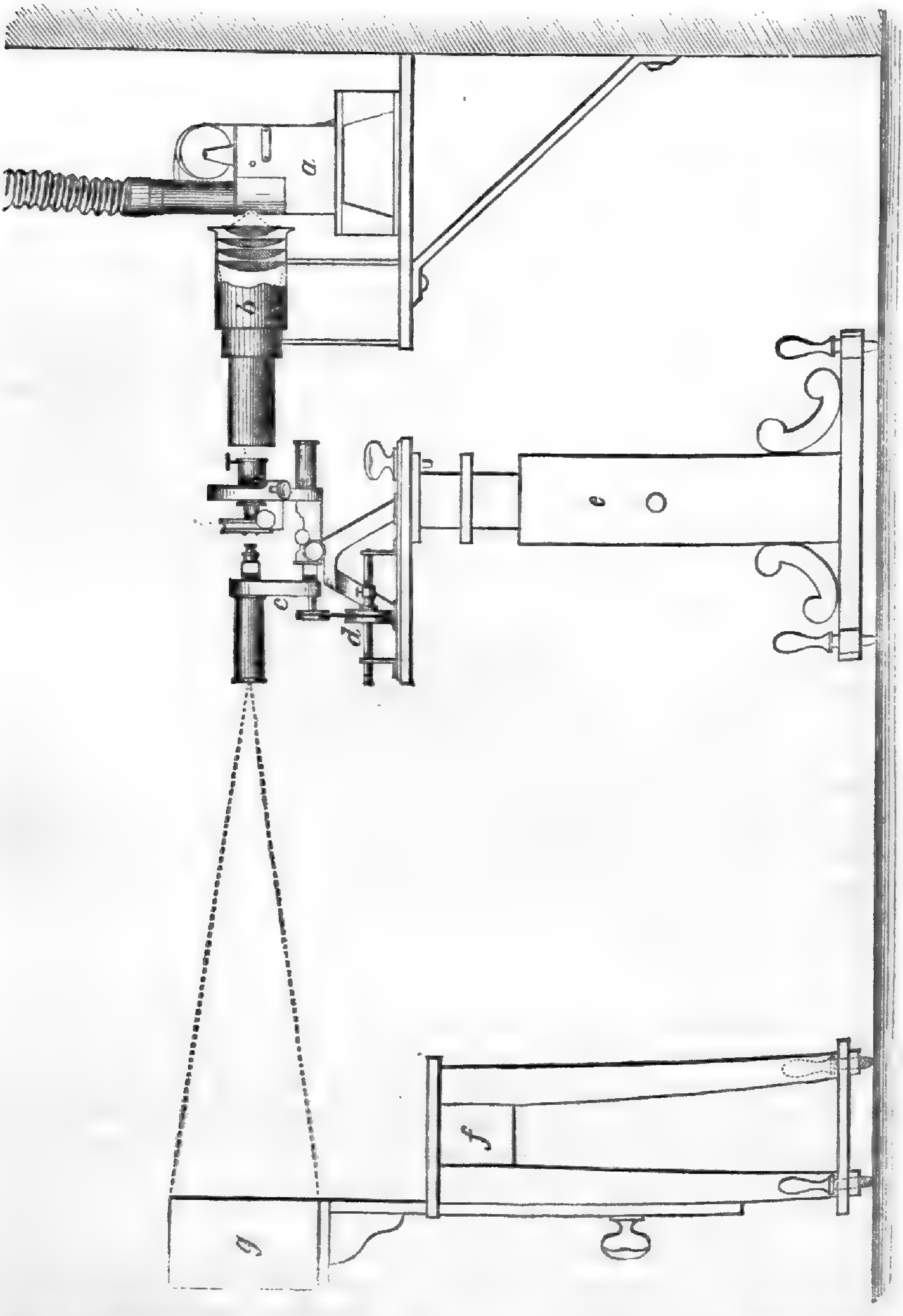
1. The electric light is by far the best of all artificial lights for the production of photo-micrographs, and, when used as I am now about to describe, it is both convenient and economical. I use a Grove's battery of fifty elements. The battery is placed just outside of the operating room in a closet from which the fumes escape through an earthen pipe into the main chimney of the building. This battery was furnished by Mr. William Ladd, Nos. 11 and 12, Beck street, Regent street, London, W. The rubber cups are $4\frac{3}{4}$ inches high, $3\frac{1}{4}$ wide and 2 thick. The platinums are $5\frac{1}{2}$ inches by $2\frac{1}{8}$, and weigh about 60 grains each. The zincs are bent on themselves so as to present a part of their surface on each side of the platinums, and weigh, when new, about a pound apiece. Mr. Ladd furnishes these batteries in

trays of ten elements, at five pounds sterling per tray, and I find that a battery of five trays is sufficient for most purposes. Seven pounds and a half of strong commercial nitric acid, and three of sulphuric, diluted with ten times the quantity of water, is sufficient to charge this battery, which will then produce the light continuously for from three to four hours. The cost of running the battery for this time, including in the estimate the amount of zinc consumed, and the cost of amalgamating every third or fourth time of using, is very moderate. I make it a practice to have the battery washed out, the acids thrown away and the porous cups put to soak immediately after I have done the day's work, and all this is so simple that I have no difficulty in instructing an orderly to do it, so that the management of the battery does not occupy any part of my time.

The Duboscq's lamp, the microscope and the plate holder are arranged in a daik room which enables me to dispense with the use of a camera. The general arrangement of the apparatus is shown in the cut.

The electric lamp of Duboscq (*a*) is placed on a stool against the wall at one end of the room, and its light concentrated by a pair of condensing lenses (*b*) on the lower lens of the achromatic condenser of the microscope. The microscope (*c*) (a large Powell and Lealand's stand) is placed on a small table (*e*) which is so arranged that it can be lowered or elevated at pleasure and can be levelled by means of three levelling screws at its base. The plate holder (*g*), also arranged so that it can be raised or lowered at pleasure, is supported by a small table (*f*) which stands on three levelling screws. The floor of the apartment is quite level. The lenses employed for the microscope are those of Mr. William Wales of Fort Lee, New Jersey, specially constructed for bringing the actinic rays to a focus. For powers above the $\frac{1}{8}$th, however, I have found that the achromatic objectives of Messrs. Powell and Lealand, of London, answer an excellent purpose, and indeed that their immersion $\frac{1}{16}$ exceeds in defining powers any objective which has as yet come under my notice.

In taking photographs with this apparatus, I proceed as follows: The electric lamp being set in motion, the table holding the microscope (which has previously been levelled), is raised or lowered and moved from side to side till the center of the achromatic condenser is brought to the center of the illuminating pencil proceeding from the lamp; the object is then placed on the stage and carefully adjusted. A cell of plate glass containing a saturated solution of the ammonio-sulphate of copper is fixed just below the achromatic condenser, and not only prevents the admission of non-actinic rays, but excludes the very great heat which accompanies the electric light, and also mode-rates its effect upon the eye of the observer. The light thus produced is very agreeable to the eye, and I find myself able to work with it from four to five hours without fatigue. It has



also the advantage that all the colors of the object examined disappear, and the preparation appears black on an azure field which resembles the sky on a clear day, so that the observer sees at a glance how the object will appear in the photograph (in which the same black lines or tints will be faithfully reproduced on a white field) and is thus enabled to arrange his achromatic condenser and other adjustments so as to produce the most satisfactory effect.

Every thing having been arranged at the microscope to the satisfaction of the observer, the eyepiece is taken out, and the image allowed to fall on the ground glass of the plate holder, which has previously been placed at the distance necessary to give the magnifying power desired with the objective employed. The operator adjusts the plate holder to the right height and sees that it is perpendicular to the optical axis of the microscope, which he readily does by observing that all parts of the field are equally in focus. He then takes out the ground glass and finishes the fine adjustment with a sheet of plate glass and a focussing glass, after which the sensitive plate is inserted, the exposure made and the operation is finished.

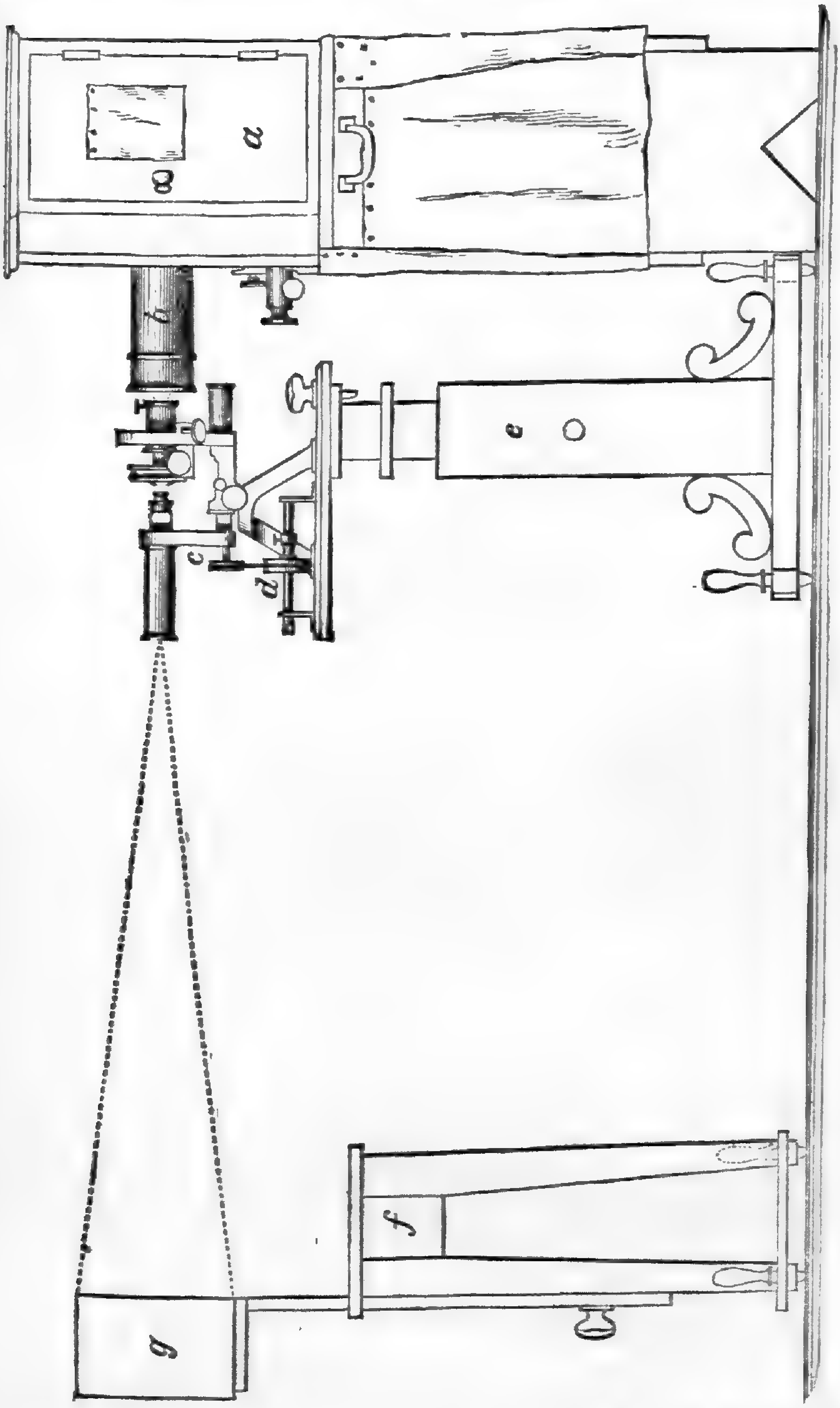
To enable the observer to focus the microscope while sitting at a distance from it at the sensitive plate, the following contrivance is employed. On the table which supports the microscope (*e*) two brass shoulders, each two inches high, are screwed. Through these runs an iron rod nine inches long, on which slips a brass pulley (*d*) which can be clamped at any point. A cord connects this pulley with the wheel of the fine adjustment of the microscope which is grooved for the purpose. It is evident that whenever this iron rod is turned, the pulley turning with it will move the fine adjustment of the microscope. To effect this the iron rod terminates in a square extremity, so that a joint of an ordinary fishing rod, to which a brass ferrule shaped like a watch key, has been rivetted, enables the operator to focus the microscope at anyordinary distance. When greater distances are required two joints of the rod may be used. The rod, being graduated into feet and inches, enables the operator to record the distance employed for each picture. When the focussing is completed, the rod is removed. I have found this simple and cheap arrangement superior in delicacy and convenience to any of the more costly arrangements, I have heretofore tried.

The chemical processes, employed in taking the negatives, do not differ in any respect from those used in ordinary photographic work, and I have found that by employing a practical photographer, allowing him to manage the dark room and confining my whole attention to the optical arrangements, I not only get many times more pictures in a day, but they are much better than can be produced by any one who attempts to do the photographic work, as well as manage the microscope himself.

I find myself thus enabled to sit down quietly of an evening, and during four hours work to produce from twelve to thirty negatives or more, in accordance with the difficulty of the subjects and my previous knowledge of them. Any microscopist who is willing to go to the moderate expense of battery and lamp, and to add two or three specially constructed objectives to his microscopical apparatus, can, by employing a photographer one or two evenings in the month, reproduce all the more interesting of his month's observations with a degree of economy and beauty not to be obtained by any other means, and if he follows the method I have above described, the character of his results will be conditioned by his skill as a microscopist rather than by any other circumstance. As to the time of exposure required for taking negatives with the electric light, I find that for one thousand diameters about thirty seconds is necessary for that class of objects, (such as Angulatum, the Nobert's plate, &c.,) for which it is not necessary to employ a ground glass plate to prevent interference phenomena. In photographing the soft tissues and many other objects, it is necessary to insert a piece of ground glass below the achromatic condenser to escape the interference phenomena which else occur, precisely as must be done in photographing the same objects by sunlight. This increases the time of exposure to about three minutes for one thousand diameters. Other powers require poportional times.

2. The magnesium light affords a beautiful source of illumination comparable to white cloud illumination of the best character, or to the light of the sun after it has passed through a sheet of ground glass. Without the use of ground glass, this light serves admirably for the production of photographs of the soft tissues with any power under a thousand diameters. The light being composed of a mixed pencil, with rays passing in all directions, there are no interference phenomena, but for the same reason, on the Nobert's plate and many test objects, the results are inferior to those produced by the sun or by the electric light; with powers much higher than a thousand diameters, however, the time of exposure becomes inconveniently long.

The process employed by me in the production of negatives with the magnesium light, is essentially the same as I have above described for the electric light, simply the magnesium lamp is substituted for the electric, and the condenser of an ordinary oxy-calcium magic lantern is made to concentrate the light on the achromatic condenser of the microscope. The cut represents the arrangement. The magnesium lamp (*a*) stands on a shelf fastened against the wall. The condenser (*b*) concentrates the light on the lower lens of the achromatic condenser of the microscope, (*c*) which stands on a table (*e*) supported on three levelling screws. The image received on the plate holder, (*g*) which is supported on a table, (*f*) is photographed precisely as in the case of the electric light as above described. The same focussing apparatus (*d*) is employed and the ammonio-



sulphate cell should invariably be inserted, but the ground glass is never necessary. I find that it requires exposures of about three minutes to produce negatives of tissue-preparations with five hundred diameters. Other powers require proportionate exposures.

The magnesium lamp used by me for this purpose was the two-ribbed lamp of the American Magnesium Company, (No. 2 Liberty Square, Boston, Mass.,) sold by that company for magic lantern purposes, price $50. The ribbon weighs about 52 centigrammes per metre, and is sold at $2.50 per ounce. Two ounces will, with care, answer for three or four hours constant work, and ought to produce from twelve to thirty negatives in accordance with the difficulties of the subjects to be represented. The fumes of magnesia resulting from the combustion are carried into a chimney five feet long, made of a spiral wire covered with muslin, which terminates in a muslin bag in which the oxyd condenses, while the draft goes on through the interstices of the muslin. The chimney and bag are furnished by the company for $2.50.

In commenting on the above processes it may be remarked that, for the anatomist and physiological investigator, the Magnesium lamp affords a satisfactory and sufficient source of light for the photography of normal and pathological tissue-preparations. The same end can be equally well or even better attained with the electric lamp, with which also the most difficult test objects can be satisfactorily reproduced. Where economy of apparatus is the object, the magnesium lamp will be preferred by ordinary workers; but where much work is to be done, the high price of the magnesium ribbon more than counterbalances the cheapness of the apparatus, and the electric light becomes the most economical. For the information of any practical photographers who may be employed for work of this character, I may add the following remarks on the chemical process employed in the production of the negatives from which the appended prints were made. An ammonium and potassium portrait collodion, rich in alcohol, was employed, developed with the ordinary solution of iron, and fixed with cyanid of potassium. Where it was necessary to intensify, the hydrosulphuret of ammonium was resorted to.

In illustration of the character of these sources of illumination as compared with each other and with sunlight, I herewith append three prints from negatives, taken with a Wales' inch and a half, from the 6th square of a Möller's diatom type-plate, specially prepared for the Army Medical Museum by that skillful microscopist. The first from Negative 79 (new series), was taken by sunlight, with 40 diameters; in the second, from Negative 123 (new series), the magnesium light was used, and every thing else remaining the same, the distance was increased so as to give 48 diameters; in the third, Negative 158 (new series), the electric lamp was employed, and every thing else still remaining unaltered, the distance was increased so as to give 66 diameters. It will be understood at once, that on account of the increase of distance, the second picture would have been slightly less sharp than the first, and the third than the second, had precisely the same source of light been employed; nevertheless, in spite of this disadvantage, to which they were purposely exposed, the magnesium and electric pictures are far superior to that taken by sunlight, and of the two the electric is much the best. It is especially to be observed, that in the electric picture the contrast obtained is so great that the objects appear clearly defined on an almost perfectly white ground, which is never the case with photo-micrographs taken with the sun as a source of illumination.

As a further illustration of the capabilities of the magnesium and electric lights, I add a few photographs taken by each.

By the Magnesium Light.

Arachnoidiscus Ehrenbergii. Magnified 400 diameters, by Wales' $\frac{1}{8}$th. Negative 114 (new series.)

Small vein and capillaries, from the muscular coat of the urinary bladder of the frog. Magnified 400 diameters, by Wales' $\frac{1}{8}$th. Negative 103 (new series). This negative is taken from preparation No. 3378, Microscopical Series, in which the bladder was injected with a half per cent solution of nitrate of silver, and subsequently stained with carmine dissolved in borax. The epithelium was then brushed off with a camel's hair pencil, and the preparation transferred through absolute alcohol to Canada balsam: the photograph reproduces every thing but the color.

By the Electric Light.

Pleurostaurum acutum. Magnified 340 diameters, by Wales' $\frac{1}{8}$th. Negative 109 (new series.)

Triceratium favus. Magnified 340 diameters, by Wales' $\frac{1}{8}$th. Negative 110 (new series).

Navicula spima. Magnified 840 diameters, by Powell and Lealand's immersion $\frac{1}{16}$th. Negative 112 (new series).

Human red blood corpuscles. Magnified 1,000 diameters, by Powell and Lealand's immersion $\frac{1}{16}$th. Negative 145 (new series).

Section of an epithelial cancer of the larynx. Magnified 400 diameters, by Wales' $\frac{1}{8}$th. Negative 162 (new series). This negative is taken from preparation No. 2277, Microscopical Section. The print shows the nuclei and cells of the growth with great distinctness.

Grammatophora marina. Magnified 2,500 diameters, by Powell and Lealand's immersion $\frac{1}{16}$th. Negative 151 (new series).

[The copies of the photographs here referred to, sent us by Dr. Woodward, surpass in perfection and beauty any specimens of photo-micrography we have seen.—Eds.]

Art. XXXI.—*On a Mechanical Finger for the Microscope;* by J. H. B. L.

In the Journal of May, 1866, there is a description and woodcut of a mechanical finger, by Mr. H. L. Smith.

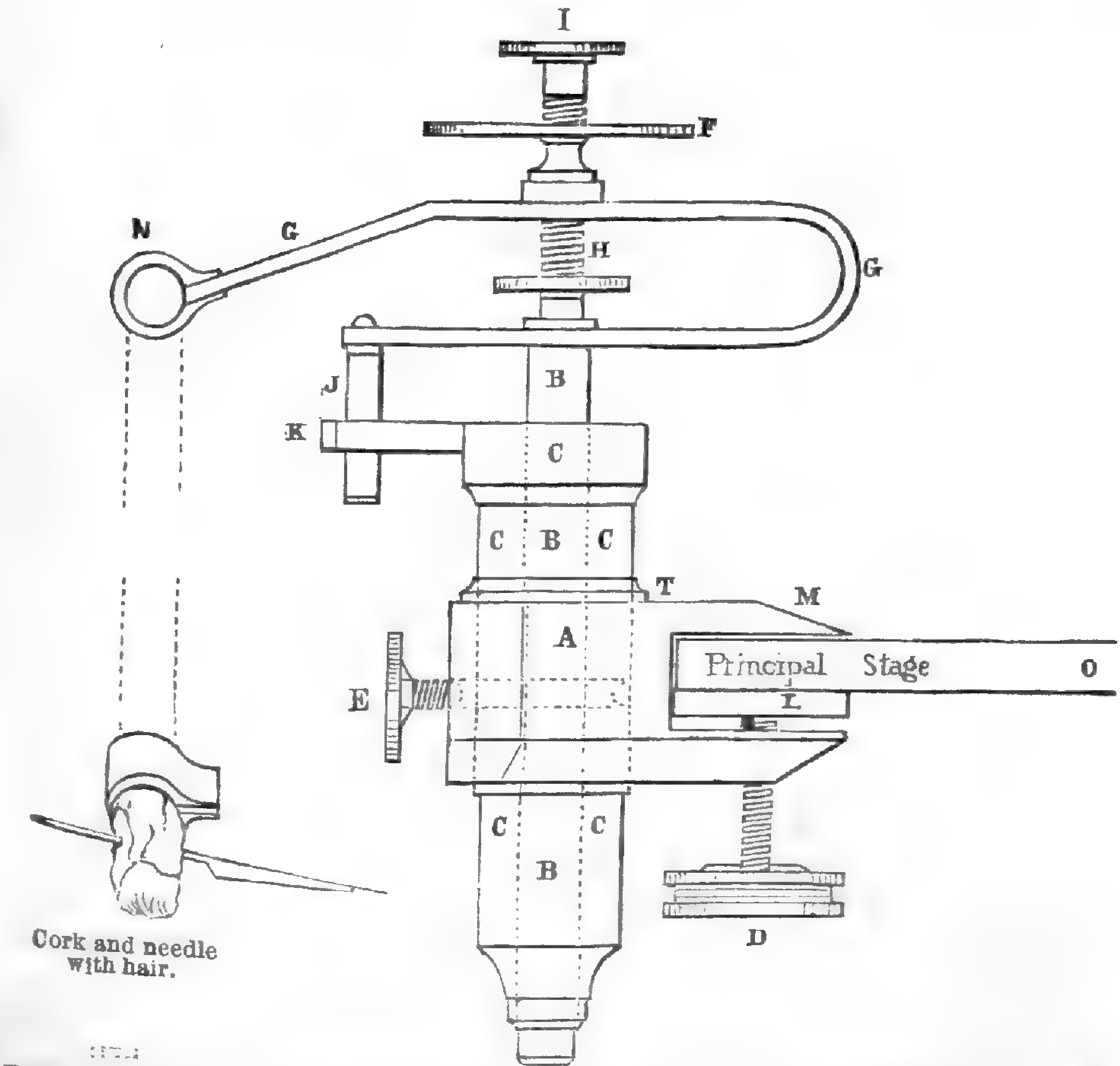
There are few naked eyes, or ordinary hands, that can select, from a mass, one of the smaller diatoms; and the engraving in the Journal was seized upon, at once, by the writer, as affording a promise of relief in the patient labor that had so often tested both his eye and hand. It was his good fortune to be within reach of one of the instruments. It was a great help, no doubt; and, after acquiring "the knack," it was possible to use it. But it wanted solidity, and the writer ventured to think that it might be made firmer, if constructed with fewer parts and joints. It was a capital idea, however, usefully illustrated; but not beyond improvement: so an improvement, as it was thought, was put on paper, and sent to Mr. Joseph Zentmayer, the well known optican of Philadelphia.

Putting aside both the improvement and the original, Mr. Zentmayer went to work upon an entirely new system, and produced what seems to be very near perfection.

The microscope, in the writer's possession, is one of Mr. Zentmayer's large first class ones, though the finger can be adapted to any other. There are three pieces: one, an independent stage, that we will call the diatom stage, (fig. 1) supported, above the principal stage, upon a tube that fits into a sleeve attached to a cylinder, (fig. 2), that fits into the sub-stage. The tube of the diatom stage is passed through the opening of the principal stage into the sleeve, as shown in the drawing, when its only movement, up and down, is regulated by the rack and pinion of the sub-stage. Light from the reflector is thrown upon the object through the tube of the diatom stage. A spring, S, with an ivory button, B, is attached to the diatom stage, as shown in fig. 4, which steadies the slide as it is moved by hand to bring different parts of it into the field.

Fig. 3 shows the third piece of the apparatus, or, really, the only piece, so far as the finger is concerned; the other three pieces being necessary to hold the slide containing the diatoms, but having, otherwise, nothing to do with the finger proper. The drawing is of full size. A is a clamp secured to the principal stage by the jaws M and the movable plate L, which is tightened by the set screw D. The cylinder C passes through the clamp resting on the shoulder T. It turns horizontally when not fixed by the set screw F, whose point presses in the groove shown in the drawing. The steel rod B, surrounded by a spiral spring, which is not shown, but which can be readily

Fig. 3.


I
F
N
G
H
G
B
J
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C
C B C
T
M
A
Principal Stage
O
E
L
C C
B
D
Cork and needle with hair.

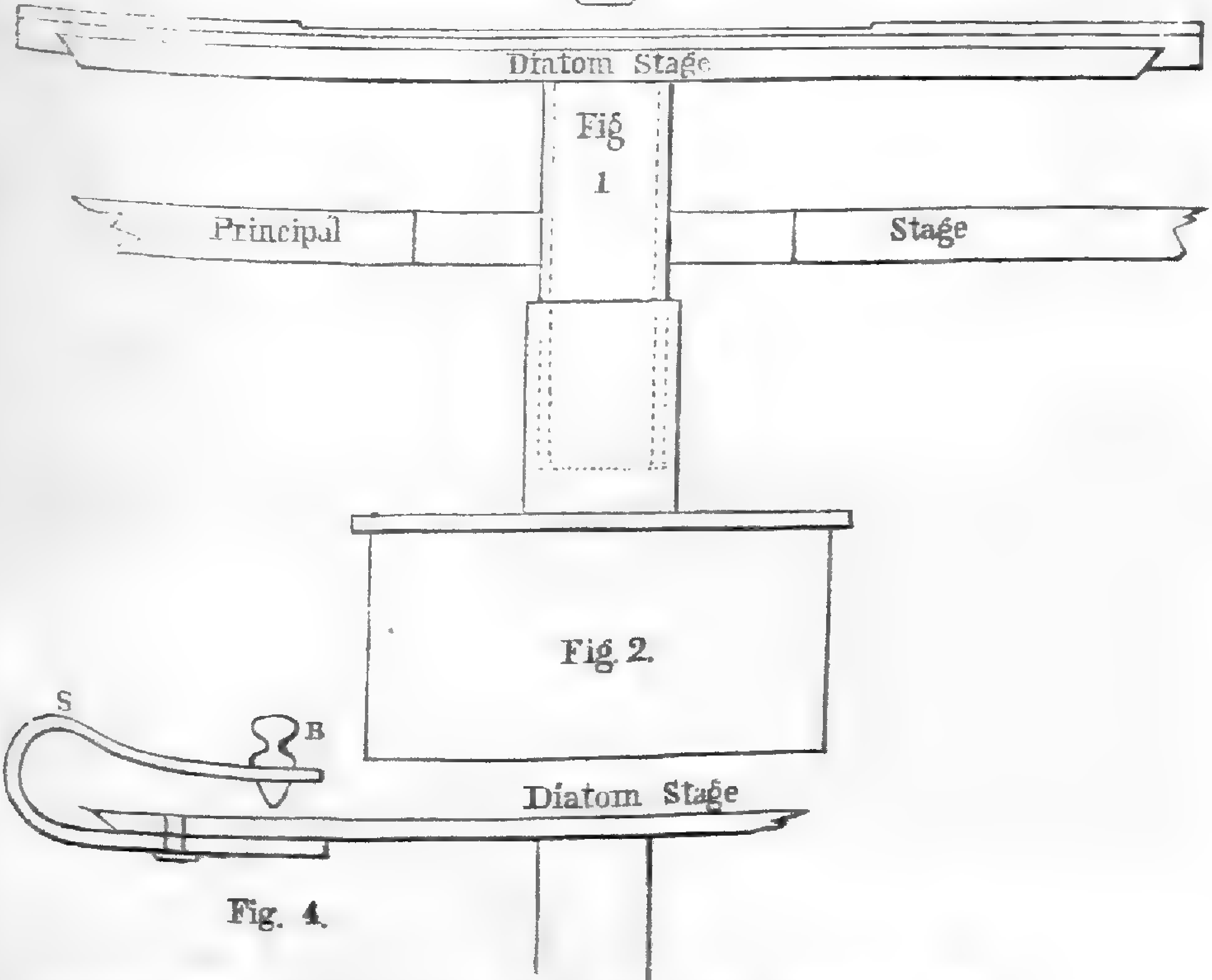

Diatom Stage
Fig 1
Principal
Stage
Fig. 2.
S
B
Diatom Stage

Fig. 4.

understood, passes through the cylinder C, the spiral holding it up when not pressed down. Upon this rod is the steel spring, G, bent as shown, carrying at its upper and longer extremity, at N, a cork-holder, through which is thrust the needle that carries the hair; and, at its lower extremity, the guide J, passing through a slot on the arm K, projecting from the cylinder C. The object of this is to counteract the rotary movement that would otherwise be caused by the spiral spring on the rod B when pressed downward in operating the apparatus. F is a large milled head lowering or raising the end of the spring N, in focussing the point of the hair. The down pressure is applied at I compressing the spiral spring around the bar B within the cylinder C, and bringing the point of the hair on the particular diatom.

A most excellent, if not an original, mode of attaching the hair to the needle, which is thrust, eye foremost, through the cork projecting from N, is the suggestion of a friend of the writer. Cut a piece of thin paper into the shape of the letter V about half an inch high and crease it lengthwise so as to bring the sides together. Having gummed the paper well, lay the needle on the crease, keeping its point within the paper, and place the hair along side of it. Then closing the sides of the V, the needle and the hair will be compressed together at the bottom of the crease; and when the paper is perfectly dry the hair can be cut with scissors to the proper length, if necessary, and so much of the paper trimmed off as may not be wanted to retain the needle and hair in their places. The needle may then be forced, with a pair of fine pliers, eye foremost, through the projecting end of the cork at an angle inclining somewhat downward; and, when this is done, the finger is ready for use. The angle of the needle to the stage may be changed by turning the cork, which is screwed into the opening at N, which has a thread for the purpose.

The slide containing the diatoms is now placed on the diatom stage; the part to be examined being over the opening of the tube, through which the light is reflected, focussed as usual, and the particular diatom selected. The hair is then brought, by hand, within the field of view. This is done by turning the cylinder C, and adjusting with the pliers, if need be, the length of needle and hair projecting through the cork. The set screw E is then tightened, and the observer has, in the field, the diatom in focus, and the end of the hair seen dimly, and not in focus. The screws of the principal or mechanical stage now enable him to bring the point of the hair with mathematical precision just above the diatom; when, pressing at I gently downward, the hair touches the diatom; the latter, if all goes well, adheres to it; the diatom stage is lowered; the slide removed; the clean slide, to which the diatom is to be transferred is put in its place; the diatom stage raised until the hair, with the diatom on it, is in contact, when the diatom is taken off by the moisture that has been previously breathed upon the slide.

The superiority of the contrivance here described is its simplicity and absolute steadiness.

In the drawing, the position of the spring G with the cork-holder N is reversed. They turn, as already described, in any direction, horizontally.

The facility with which a diatom may "be handled," to use the term in this connection, is one of the great advantages of Mr. Zentmayer's contrivance. The point of the hair may be brought into focus along side of the diatom, which may then, by using the screws of the mechanical stage, be pushed in any direction by the finger, and separated from the mass, or, when transferred to a clean slide, may be placed wherever required thereon. With such an instrument may be understood the *modus operandi* by which the 392 diatoms of "Möller's Diatomaceen platte" were arranged.

Nothing more has been attempted here, than to describe the particular instrument. But no one can understand the whole subject, without reading the most admirable article of Mr. H. L. Smith already referred to, and which set the writer to work to improve, if possible, the mechanism there described. L.

ART. XXXII.—*The Combinations of Silicon with Alcoholic Radicals;* by C. FRIEDEL and J. M. CRAFTS.*

IN a previous research† we studied the ethers of silicic acid, and discovered a number of new bodies, whose structure leads to the conclusion that the atomic weight of silicon is 28, and that the formula of silicic acid is SiO_2. Gaudin, and afterwards Odling, first gave silicon its true atomic weight, and silicic acid its rational formula, in order to bring them into accordance with the well known law establishing the most simple relation between the vapor density of bodies and their atomic weight, and their views have been adopted by many chemists; but hitherto conclusive proofs, based upon chemical grounds, have been wanting to establish completely the correctness of their theory, and a large number of the best authorities in chemistry have adhered to the old formula, $SiO_3(O=8)$ for silicic acid.

Our research was at first undertaken with a view to proving that the chemical properties of silicates can only be explained by adopting the new formula, and we have succeeded in obtain-

* The chemical symbols used have the values which belong to them in the new system.

† This Journal, II, xliii, pp. 153 and 331; Ann. de Chim. et Phys., IV, ix, p. 5.

ing bodies, whose existence and mode of formation it is impossible to account for by any other theory. Such are the chlorhydrids and acetins derived from normal silicic ether, $Si(C_2H_5O)_4$ and at first we only studied the compounds which belong to the same type as the normal silicic ether, but the research led us further than we anticipated, and resulted in the discovery of the more complicated disilicic ethers, already described, whose structure throws some light on the rational formulas of mineral silicates, and also of a remarkable class of bodies, in which the alcoholic radicals, ethyl, C_2H_5, and methyl, CH_3, are combined directly with the silicon, and not, as in the ethers, through the medium of oxygen. The present paper is devoted to the description of these latter bodies.

The study of the compounds of silicon with alcoholic radicals fortifies the conclusions already arrived at; it demonstrates the tetratomicity of silicon, and places it in the same group with tin, titanium and carbon; and it leads, besides, to the discovery of a property of silicon, which allies that element with carbon far more closely than the equality of their atomicity and the similarities hitherto observed in the structure of their compounds. In fact, silicon has been found to possess the property of combining directly with carbon, or rather with hydrocarbons; and the resulting compounds are in every respect similar to simple hydrocarbons, susceptible like them of substitution of chlorine and bromine for hydrogen, and of acting as radicals in alcohols and ethers; consequently silicon may take the place of carbon in a hydrocarbon, and in the series of bodies which can be derived from a hydrocarbon, without modifying essentially its properties.

It is easy to appreciate the importance of this result. Carbon is characterized by the property of combining with itself to build up groups of atoms, which have been compared to chains, or nuclei, about which the atoms of hydrogen, oxygen, nitrogen, &c., found in organic bodies, group themselves, and it is especially this property of carbon which fits it to play the part of the element essential to the structure of organic compounds.

It has been supposed that carbon alone had the property of combining with itself to form the nuclei of organic compounds, but it now appears that silicon shares with it this quality, and we are led to the opinion, that no element is unique in its properties, but that each has its near relatives among the others, as was indicated by Dumas in dividing the elements into natural families, and as every new discovery daily tends to prove. It is remarkable, also, that analogies of this kind, which are independent in their nature of the atomicities of the elements, should occur especially between elements having the same atomicity, and the fact enhances the value of a classification of the elements, which is founded upon the consideration of their atomicities.

Silicic Ethyd.

We have obtained silicic ethyd by the reaction which is often employed to effect the union of ethyl with metals or with non-metalic elements. Chlorid of silicon and zinc-ethyd do not act upon each other at the ordinary temperature, but when they are mixed in the proportion requisite to afford an equivalent of zinc for each atom of chlorine, and heated in sealed tubes to 140° centigrade, a reaction commences, and at 160° it is completed in 3 hours. On opening the tubes, a considerable quantity of a gaseous hydrocarbon escapes, which, when lighted, burns with a luminous flame. The tubes contain a liquid, together with a solid deposit of chlorid of zinc, mixed with gray particles of metallic zinc. The presence of metallic zinc accounts for the production of gaseous hydrocarbons.

The liquid can be separated by distillation into several products. It commences to boil at 40°, and at that temperature chlorid of silicon distils, mixed with a very volatile hydrocarbon, burning with a luminous flame, which cannot be condensed alone at 0°, but which is held in solution, to a considerable extent, by the chlorid of silicon. When the temperature reaches 60°, nearly pure chlorid of silicon distils, and it then rises rapidly to 150°, and the greater part of the liquid distils at 150° to 155°.

The portion which distils at 60° to 150°, treated with water, gives the products of decomposition of the chlorid of silicon, together with a certain quantity of a liquid, identical in its properties with that which distils at 150° to 155° in the first operation. The portion thus obtained in both operations, distilling at 150° to 155°, washed with water and with a solution of caustic potash, to free it from the small quantities of chlorid of silicon which can not be easily separated by distillation, and then dried over solid caustic potash, distils at 152° to 154°. The body thus obtained is not spontaneously inflammable, like many of the compounds of organic radicals with metals, but when ignited it burns in the air with a luminous flame, and gives off a white smoke of silicic acid. It is lighter than water, and is not attacked by caustic potash nor by ordinary nitric acid. It is also not attacked by sulphuric acid, and is insoluble in it; concentrated sulphuric acid, however, separates from it a small quantity of a body which will be described later. It can be completely purified by shaking it several times with concentrated sulphuric acid, and decanting by means of a pipette; finally by washing with water and by drying over melted chlorid of calcium. The product, which was finally obtained by operating in this way on considerable quantities of material, boiled at 152°.

The method of purification with sulphuric acid was not at first adopted, and the analyses made of the substance boiling at about 152°, after it had been simply treated with water and with caustic potash, in order to remove traces of chlorid of silicon, gave a slight excess of carbon for the first portions which distilled; see analysis I. This was undoubtedly due to a minute quantity of a hydrocarbon, probably ethylene, dissolved in the liquid.

The analyses of the portions which distilled last showed on the other hand a deficiency of carbon, arising from the presence of a body containing oxygen, which can be separated by means of concentrated sulphuric acid; see analyses II and III. We noticed, also, that the liquid was at first capable of absorbing a very small quantity of bromine, without being colored by it. After the treatment with sulphuric acid, the boiling point of the liquid was almost constant, and the smallest trace of bromine imparted its color to it, showing that no combinations took place.

Analysis of the liquids, which had not been treated with sulphuric acid.

I. *Boiling point*=151°–151½°.
Substance taken=0·1863 *grammes;* CO_2=0·4520 *grammes;* H_2O=0·2280 *grms.*

II. *Boiling point*=151½°–153°.
Substance taken=0·1743 *grms.;* CO_2=0·4127 *grms.;* H_2O=0·2170 *grms.*

III. *Same product redistilled.* Boiling point=151½°–152½°.
Substance taken=0·1943 *grms.;* CO_2=0·4685 *grms.;* H_2O=0·2390 *grms.*

	I.	II.	III.	Calculated for $Si(C_2H_5)_4$
C	=67·13	65·93	65·77	66·67
H	=13·60	13·83	13·67	13·89

Analyses of silicic ethyd purified by a treatment with sulphuric acid. Boiling point=152°–153°.

I. *Substance taken*=0·1931 *grms.;* CO_2=0·4705 *grms.;* H_2O=0·2388 *grms.*

II. *Substance taken*=0·2192 *grms.;* CO_2=0·5358 *grms.;* H_2O=0·2720 *grms.*

III. *Substance taken*=0·3015 *grms.;* SiO_2=0·1250 *grms.*

IV. *Substance taken*=0·3430 *grms.;* SiO_2=0·1395 *grms.*

	I.	II.	III.	IV.	$Si(C_2H_5)_4$.
C=	66·45	66·66	....	....	66·67
H=	13·74	13·79	....	....	13·89
Si=	....	....	19·34	18·98	19·43

The first determination of silicon was made by heating the substance in a sealed tube with nitric acid for several hours, at 180°–190°, dissolving the contents of the tube in caustic potash, and estimating the silicic acid in the solution in the ordinary way. In the second determination, dilute chlorhydric acid and chlorate of potassium were substituted for the nitric acid, and the operation was carried on in a sealed tube as before. It is somewhat difficult to dissolve all the silicic acid which adheres to the tube by caustic potash.

The vapor-density of silicic ethyd was deduced from the following data:

Difference of weights of the bulb - -	=0·5248 *grms.*
Temperature of the balance, - - -	14°
Temperature of the oil-bath, - -	214°·2
Barometer, - - - - - -	761·4 *mm.*
Capacity of the bulb, - - - -	211·0 *cc.*
Air remaining in the bulb, - -	1·3 *cc.*

Vapor-density=5·141.

Calculated vapor-density, 4·986.

The results thus obtained show that silicic ethyd corresponds to the chlorid of silicon, and that the reaction by which it is formed may be expressed by the equation:

$$SiCl_4 + 2Zn(C_2H_5)_2 = Si(C_2H_5)_4 + 2ZnCl_2.$$

Silicic ethyd is a liquid resembling bodies of the petroleum class in its aspect. It has an odor like the pure hydrocarbons of this series, and cannot be easily distinguished from them, except that instead of burning with a carbon-smoke, it gives a white smoke of silicic acid.

The density of the liquid at 22°·7 compared with that of water at the same temperature, is 0·7657.

In order to obtain considerable quantities of silicic ethyd, we used Frankland's copper digester instead of glass tubes, which add to the inconvenience resulting from their small capacity, that of being liable to explode from the pressure of the gases formed as secondary products of the reaction.

In the digester, 100 grms. of zinc-ethyd were operated upon at once, and an excess of chlorid of silicon was always added. The first portions, which distilled below 140°, were a mixture of chlorid of silicon with silicic ethyd, and they were always treated over again with a fresh quantity of zinc-ethyd in the next operation.

We usually heated the digester in an oil-bath, at 180°–200°, using a gas-regulator of similar construction to Bunsen's, and kept each charge at that temperature for about ten hours. After opening the digester and distilling up to 140°, water was added and the distillation continued as long as any silicic ethyd continued to pass over with the vapor; the apparatus was then cleaned and a new operation commenced. As an example of a number of such operations, we may cite one series in which 769 grms. of zinc-ethyd and 480 grms. of chlorid of silicon were employed. We obtained 225 grms. of perfectly pure silicic-ethyd—about half the theoretical quantity.

In order to understand the phase of the reaction, which results in the formation of gaseous products, and of metallic zinc, we examined the gases, which were given off on opening the digester, by passing them through bromine, freeing the gas, which was not absorbed, from the excess of bromine, and collecting it over mercury. The quantity evolved in an operation is very large, and there was no difficulty in using the first portions of the gas to remove the air from the apparatus containing bromine, and in collecting at the end a perfectly pure sample for analysis.

The analysis of the gas, which was not absorbed by bromine, gave:

Volume of the gas - - - -	= 5·17
Oxygen added - - - - -	27·72
Contraction - - - - - -	13·10
Carbonic acid - - - - -	10·26
Remaining oxygen determined by detonation with H - - -	9·50

Consequently two volumes of the gas contained 6·12 volumes of H, and 1·98 volumes of carbon vapor.

A second analysis gave:

Volume of gas - - - - -	= 6·66
Oxygen added - - - - -	26·61
Contraction - - - - - -	17·30
Carbonic acid - - - - -	13·02
Remaining oxygen - - - -	2·94

Two volumes of the gas contained 6·36 volumes of H, and 1·96 volumes of carbon vapor.

The gas was the hydrid of ethyl C_2H_6, two volumes of which contain six volumes of hydrogen and two volumes of carbon vapor.

The bromid which was obtained by the absorption of a part of the gas by bromine, after having been washed with a solution of caustic potash, dried and distilled at 132°–134°, was analyzed with the following result:

I. *Substance* =0·3695 *grms.*; *AgBr*=0·7315 *grms.*

II. *Substance*=0·2712 *grms.*; CO_2=0·1330 *grms.*; H_2O=0·0608 *grms.*

III. *Substance*=0·3259 *grms.*; CO_2=0·1600 *grms.*; H_2O=0·0690 *grms.*

	I.	II.	III.	Calculated for $C_2H_4Br_2$
C	....	13·35	13·42	12·76
H	....	2·47	2·35	2·12
Br	84·43	....	....	85·11

The body is consequently the bromid of ethylene, and the gases, which are formed during the preparation of silicic ethyd, are simply those which are known to arise from the decomposition by means of heat of zinc-ethyd.

The question suggests itself: are intermediate products, arising from an incomplete replacement of chlorine by ethyl in the chlorid of silicon, also formed? Such products should have the composition: $Si(C_2H_5)_3Cl$; $Si(C_2H_5)_2Cl_2$; $Si(C_2H_5)Cl_3$, and should boil at points intermediate between 152°, the boiling point of silicic ethyd, and 42°, the boiling point of chlorid of silicon. The question must be answered in the negative; for after a large number of fractionated distillations of the product obtained in an operation, where a considerable excess of chlorid of silicon was used, it could be separated almost completely into chlorid of silicon and silicic ethyd, and no bodies appeared with fixed boiling points between 42° and 152°. The small quantity of liquid, which was eventually obtained, distilling between these points, was treated with caustic potash, and gave no more of a compound containing oxygen than was ordinarily obtained in every preparation of silicic ethyd, and whose mode of formation is described below.

We failed also to obtain intermediate compounds on heating chlorid of silicon and silicic ethyd together in sealed tubes for 15 hours, at a temperature of 240°. The product could easily be separated by repeated distillation into the two bodies which were originally mixed.

It appeared probable that silicic ethyd, and perhaps intermediate bodies, might be formed by a process analagous to that employed by Frankland and Duppa* to obtain boric-ethyd, $B(C_2H_5)_3$, namely: by the action of zinc-ethyd upon normal silicic ether. We found, however, that the two bodies do not act upon each other, even at a very high temperature; indeed the tenacity with which silicon retains its hold upon oxygen renders this result not surprising.

A most interesting phase of the reaction between zinc-ethyd and chlorid of silicon, is the one which gives rise to the formation of the body containing oxygen, which has been noticed above. As has been already stated, concentrated sulphuric acids frees the crude silicic ethyd from a small quantity of a foreign body, which is soluble in the acid. This body separates from the solution when the sulphuric acid is diluted with water,

* Annales de Chimie et Pharmacie, cxv, 319.

and floats upon the surface of the solution. It burns with a siliceous smoke, has a disagreeable odor until it has been purified by repeated distillations, and boils at about 235°. The product, which was purified as far as possible by a number of distillations, was analyzed.

I. *Substance*=0·1861 *grms.*; CO_2=0·4090 *grms.*; H_2O=0·2068 *grms.*

II. *The product of another operation, whose boiling point was* 229°–235°. *Substance*=0·2535 *grms.*; CO_2=0·5363 *grms.*; H_2O= 0·2855.

I.	II.	Calculated for $O\begin{cases}Si(C_2H_5)_3\\Si(C_2H_5)_3\end{cases}$
C=59·94	57·71	58·54
H=12·34	12·51	12·19

Only a small quantity of this body is produced in the preparation of considerable quantities of silicic ethyd, and we have not succeeded in isolating it in a perfectly pure state during that preparation; its composition is, however, not doubtful, and we were able to recognize its identity with the same oxyd, which can be easily obtained and purified by a method described below. This oxyd must be derived from the oxyd of zinc, which is formed by the action of the air upon zinc-ethyd while charging the digester. Friedel and Ladenburg* have found that free and combined oxygen can be substituted for a part of the chlorine in chlorid of silicon, with formation of the oxychlorid, $O\begin{cases}SiCl_3\\SiCl_3\end{cases}$. This oxychlorid is probably formed in the digester from the oxyd of zinc, and acts upon the zinc-ethyd to form the oxyd $O\begin{cases}Si(C_2H_5)_3\\Si(C_2H_5)_3\end{cases}$, whose analysis is given above.

This oxyd may be considered as the ether of the radical silicic-triethyd $O\begin{cases}Si(Et)_3\\Si(Et)_3\end{cases}$, and as analogous with the simplest ether of the ordinary series, $O\begin{cases}CH_3\\CH_3\end{cases}$, silicon replacing the carbon, and ethyl the hydrogen. It is more difficult to decompose than the ordinary ethers, and resists the action of many of the agents which remove radicals from common ether; one of us, however, has succeeded in obtaining a double decomposition by means of the chlorid of acetyl; but the study of the products of the reaction is not yet completed.

Action of Bromine on Silicic Ethyd.

Nothing distinguishes silicic ethyd more completely from the compounds hitherto obtained by the action of the chlorids of

* Comptes Rendus de l'Académie des Sciences, lxvi, 539.

the elements on zinc-ethyd, than the manner in which it acts with bromine and chlorine; thus far the only reaction known for such bodies is that in which the union between the alcoholic radical and the other element is severed, and the bromine or chlorine takes the place of the alcoholic radical.

The researches for instance, which have been made by several chemists* on stannic-ethyd, show that the action of bromine on that body is represented by the equation; $Sn(C_2H_5)_4+Br_2=Sn(C_2H_5)_3Br+C_2H_5Br$. We expected a precisely similar reaction with silicic ethyd, and were surprised to find that the ethyl was held so strongly by the silicon, that it could not be removed by bromine or by chlorine, and that the only action was a substitution of the bromine or chlorine for hydrogen in the organic radical.

Bromine does not attack pure silicic ethyd at the ordinary temperature; but when two atoms of bromine are heated in a sealed tube with silicic ethyd for 1½ hours at 140°, the color of the bromine disappears completely, and on opening the tube a large quantity of bromhydric acid escapes, while not a trace of bromid of ethyl can be obtained by heating the liquid. The contents of the tube distil at 160°—260°, leaving a small quantity of carbonized matter as a residue.

We could not succeed in isolating a product with a constant boiling point by fractionated distillation.

The portion of the liquid which distilled 230°—240° appeared to have nearly the composition of the mono-bromated compound, but, on redistilling, the portion which distilled at a lower temperature, 220°—230°, was found to contain less carbon and hydrogen, and there was an appearance of decomposition during the distillation.

I. *Boiling-point* =230°–240°. *Substance* =0·2990 *grms.*; CO_2= 0·4810 *grms*; H_2O=0·2400 *grms.*

II. *Boiling-point*=220°–230°. *Substance*=0·3245 *grms.*; CO_2= 0·4920 *grms*; H_2O=0·2400 *grms.*

III. *Same substance*=0·6250 *grms.*; *AgBr*=0·5051 *grms.*

	I.	II.	III.	Calculated for $SiC_8H_{19}Br$.
C	43·8	41·30	----	43·65
H	8·8	8·21	----	8·52
Br	----	----	34·38	35·87

We suspected that the portion of the liquid having the highest boiling point might contain a dibromated product, and, after a distillation in vacuo, analyzed a body which distilled at 120°–140°.

* Frankland, Annalen der Chem. und Pharm., lxxxv, p. 329; cxi, p. 44. Buckton, ibid, cix, p. 218; cxii, p. 220; Cahours, Annales de Chim. et Phys., III, lxii, p. 276.

I. *Boiling-point*=120°–140° *in vacuo.* *Substance*=0·4600 *grms.* *AgBr*=0·5360 *grms.*

I.	Calculated for $SiC_8H_{18}Br_2$.
Br=48·70	52·98

Not succeeding in obtaining a pure monobromated silicic ethyd, we heated the first product analyzed with acetate of silver with the intention of obtaining an acetate, and finally of obtaining from the acetate by saponification with caustic potash an alcohol. The formulas of the bodies thus sought are, $SiC_8H\ C_2H_3O_2$ and $SiC_8H\ HO$. Neither of them, however, were produced, and we obtained no better result by heating the bromated product to 200° with an alcoholic solution of acetate of potassium. The treatment with caustic potash of the product which had been heated with salts of acetic acid failed to extract the slightest trace of acetic acid, showing that no acetate had been formed and the principal body which was obtained was the oxyd, $O\left\{\begin{matrix}Si(C_2H_5)_3\\Si(C_2H_5)_3\end{matrix}\right.$, whose formation we had already noticed in the preparation of silicic ethyd. This product boiling at 228°–231° was analyzed.

I. *Boiling-point*=228°–231°. *Substance*= 0·2222 *grms.*; CO_2= 0·4743 *grms.*; H_2O=0·2417 *grms.*

We found that the same oxyd was produced, whether the bromine were removed from the bromated silicic ethyd by treatment with acetate of silver, acetate of potassium or caustic potash. An analysis was made of a product which was obtained by heating the bromated silicic ethyd repeatedly with solid caustic potash, and which boiled at 230—235°.

II. *Boiling-point*=230°–235°. *Substance*=0·3305 *grms.*; H_2O =0·3660.

I.	II.	Calculated for $O\left\{\begin{matrix}Si(C_2H_5)_3\\Si(C_2H_5)_3\end{matrix}\right.$
C=58·21	58·75	58·54
H=12·09	12·30	12·19

The last product was not entirely pure but contained a trace of bromine, and it is very difficult to remove the bromine completely from the bromated product, even by a prolonged action of solid caustic potash. Several analyses which were made of the liquid, which had not been treated so long a time with caustic potash, showed that it still contained a considerable quantity of bromine.

It appears from these data that the bromated silicic ethyd, when treated with substances containing oxygen combined with metals having a strong affinity for bromine, loses the atom of ethyl in which the bromine was contained and takes up oxygen in its place. The reaction is probably represented by the equation:

$$2Si(C_2H_5)_3C_2H_4Br + 2KHO = O \left\{ \begin{array}{l} Si(C_2H_5)_3 \\ Si(C_2H_5)_3 \end{array} \right. + 2KBr + H_2O + C_2H_4.$$

When a small quantity of iodine is added to the bromine, bromid of ethyl is formed by their joint action upon silicic ethyd at 140°.

The bromid of ethyl thus obtained, distilling at about 40°, was analyzed.

I. *Substance*=0·6755 *grms.*; CO_2=0·5565 *grms.*; H_2O=0·2855 *grms.*

	Calculated for C_2H_5Br.
C=22·42	22·01
H= 4·70	4·58

Iodine is almost entirely without action upon silicic ethyd: 2 equivalents of iodine were heated with one equivalent of silicic ethyd at 180° for 12 hours, very little iodhydric acid and not a trace of iodid of ethyl were formed. It is well known that all the other ethyds, obtained by a reaction similar to that which gives rise to silicic ethyd, are easily decomposed by iodine with the formation of iodid of ethyl.

The Oxyd of Silicic Tri-ethyd.

The reaction given above offers the most convenient means for obtaining the oxyd in considerable quantity, while its solubility in concentrated sulphuric acid, which has already been used to separate it from the pure silicic ethyd, serves also to free it from the traces of the bromated product, which remain after the action of caustic potash has been carried as far as possible. On treating the product analyzed above, No. II, with sulphuric acid a small quantity of a gas, which did not contain bromine was given off, and a small quantity of silicic ethyd containing a little bromine remained insoluble in the sulphuric acid. The presence of silicic ethyd accounts for the slight excess of carbon and hydrogen of analysis II. The larger part was dissolved in sulphuric acid and was separated from its solution by diluting with water. After having been washed with water and dried, ¾ of it distilled at 228°—230°.

I. *Boiling-point* =228°–230°. *Substance*=0·1970 *grms.*; CO_2= 0·1495 *grms.*; H_2O=0·2160 *grms.*

II. *Same substance*=0·2860 *grms.*; SiO_2=0·1345 *grms.*

The determination of silicic acid was made by heating the liquid in a sealed tube with strong nitric acid.

I.	II.	Calculated for $O \left\{ \begin{matrix} Si(C_2H^5)_3 \\ Si(C_2H_5)_3 \end{matrix} \right.$
C=58·07	----	58·54
H=12·18	----	12·19
Si=----	21·93	22·76

The density of vapor of the oxyd of silicic triethyd was obtained from the following data:

Difference of weights of the bulb=	1·2245 *grms.*
Temperature of the balance,	13°
Temperature of the oil-bath,	285°
Barometer,	760·0^{mm}
Capacity of the bulb,	284·0 *c. c.*
Air remaining,	1·3 *c. c.*
Vapor density,	=8·698
Calculated for $O \left\{ \begin{matrix} Si(C_2H_5)_3 \\ Si(C_2H_5)_3 \end{matrix} \right.$	8·51

Action of Chlorine on Silicic Ethyd.

When dry chlorine gas is passed into silicic ethyd in a vessel surrounded by cold water, the liquid is at first colored yellow by the absorption of chlorine; suddenly this coloration disappears and chlorhydric acid is disengaged, and from that time forward chlorhydric acid is disengaged as fast as the chlorine is absorbed, and no further coloration takes place. Not even a trace of chlorid of ethyl is produced. In order to avoid the formation of products containing too large a proportion of chlorine, the operation is interrupted from time to time and all of the liquid, which boils at a temperature lower than 160°, is distilled off, and the distillate is treated as before with chlorine. Finally the residues thus obtained are subjected to a fractional distillation.

Although we operated on a considerable quantity of silicic ethyd, and made a large number of fractional distillations of the chlorated product, we were unable to isolate bodies having constant boiling points and corresponding in composition to the mono- and bi-chlorated silicic ethyd. Analyses were made of the products which distilled at different temperatures after a number of fractional distillations.

I. *Boiling-point* =180°–190°. *Substance*=0·2120 *grms.*; CO_2= 0·4210; H_2O=0·2085 *grms.*

II. *Same substance*=0·3370 *grms.*; *AgCl*=0·2670 *grms.*

Repeated distillation decomposes partially the chlorated compound, and products having the same boiling-point contain a smaller amount of carbon and hydrogen after they have been distilled a number of times.

III. *This analysis was made from a liquid whose boiling-point was* 180°—185°, *but which had been distilled a larger number of times than the last.*
Substance=0·2540 *grms.* CO_2=0·4750 *grms.*; H_2O=0·2432 *grms.*

The following analyses were made of products belonging to the same series of distillations as the first.

IV. *Boiling-point*=190°-200°. *Substance*=0·2585 *grms.*; CO_2 =0·4785 *grms.*; H_2O=0·2280 *grms.*
V. *Same substance*=0·3135 *grms.*; *AgCl*=0·3238 *grms.*
VI. *Another product boiling at* 190°-200°. *Substance*=0·2345 *grms.* CO_2=0·4400 *grms.*; H_2O=0·2145.

The composition of all these products approaches that of monochlorated silicic ethyd.

	I.	II.	III.	IV.	V.	VI.	Calculated for $SiC_8H_{19}Cl$.
C=	54·15	----	51·00	50·48	----	51·17	53·72
H=	10·92	----	10·63	9·80	----	10·06	10·64
Cl=	----	19·39	----	----	25·51	----	19·00

Corresponding results were obtained in the analysis of several other products distilling at about the same temperature.

Two products boiling at a higher temperature had nearly the composition of the dichlorated silicic ethyd.

I. *Boiling-point* =200°-210°. *Substance* =0·2245 *grms.*; CO_2= 0·3875 *grms.*; H_2O=0·1817.
II. *Boiling-point*=205°-210°. *Substance*=0·2435 *grms.*; CO_2= 0·4155 *grms.*; H_2O=0·2015 *grms.*

	I.	II.	Calculated for $Si C^8H_{18}Cl_2$.
C=	47·11	46·53	45·07
H=	8·99	9·19	8·45

The decomposition during distillation is so rapid in the neighborhood of 230°, that it was pushed no further. According to the above analysis the boiling point of monochhlorated silicic ethyd is about 180°, and the boiling point of dichlorated silicic ethyd is about 210°.

After having thus endeavored in vain to isolate the monochlorated and dichlorated products, we noticed that after a large number of fractional distillations a considerable portion distilled at 190°-195°, and we made an analysis of this product.

I. *Boiling-point* 190°-195°. *Substance*=0·2740 *grms.*; CO_2= 0·4930 *grms.*; H_2O=0·2380 *grms.*

	I.	$SiC_8H_{19}Cl$.	Mean.	$SiC_8H_{18}Cl_2$.
C=	49·07	53·72	49·39	45·07
H=	9·65	10·64	9·54	8·45

It appears that, in a mixture of equal equivalents, the two chlorated products have a tendency to distil together at a constant temperature. Bauer* has noticed an analogous fact in regard to the bromids of ethylene and propylene.

Distillation having been found ineffectual to separate the chlorated silicic ethyds, we sought to obtain a separation of these products, or better still, of their derivatives, by chemical means, and in this, after a number of experiments, we succeeded.

We noted that the chlorated products are not attacked by an alcoholic solution of acetate of potassium, except at a high temperature, and also that the one containing two atoms of chlorine is more easily attacked than the other. In fact, the product containing most chlorine is destroyed at a temperature of 130° to 140°, while the monochlorated product is not acted upon at that temperature, and it can be separated from the other by taking advantage of this property.

The chlorated bodies distilling at 180° to 200°, were heated for 3 to 4 hours, at 130° to 140°, in sealed tubes, with an excess of melted acetate of potassium dissolved in absolute alcohol. Chlorid of potassium is precipitated, and on opening the tubes a combustible gas is disengaged. On adding a considerable quantity of water to the contents of the tubes, the salts are dissolved, and an oily liquid is separated. This liquid, after having been washed with water and dried, was treated with strong sulphuric acid, in which the monochlorated silicic ethyd is insoluble, while the products of decomposition of the higher chlorated compounds are soluble. These last seem to consist principally of the oxyd of silicic triethyd.

The insoluble liquid was drawn off by means of a pipette, washed with water, dried and distilled. We did not attempt to free it from the slight quantity of silicic ethyd which it contained, for fear of losing too much of the product, but preferred to use it for the following reaction. The liquid obtained by the process described above, distilling 180° to 190°, was sealed in a tube, with an alcoholic solution of acetate of potassium, and heated at a higher temperature than before, namely, at 180°, for several hours.

The Acetic Ether and the Alcohol of Silicic Ethyd.

At 180°, the monochlorated product is acted upon by acetate of potassium, chlorid of potassium is formed, and on opening the tube no disengagement of gas is noticed, as in the case of the higher chlorated products. After adding water to the contents of the tube, a liquid separates out, which is mostly soluble in concentrated sulphuric acid. The treatment with sulphuric

* Bulletin de la Société Chimique, i, p. 203.

acid was resorted to in order to purify the principal product from a small quantity of the undecomposed chlorated product, and of silicic ethyd, which remain insoluble. The solution in sulphuric acid was carefully decanted and slowly poured into a flask containing a considerable quantity of water in order to avoid an elevation of temperature. An oily liquid separated on the surface, which, after having been washed and dried with chlorid of calcium, distilled almost completely at 208° to 214°. It had a faint ethereal odor, and smelt also of acetic acid. It burnt with a luminous flame and a smoke of silicic acid.

This liquid proved to be the acetate derived from silicic ethyd by the reaction which is represented by the following equation: $SiC_8H_9Cl+KC_2H_3O_2=SiC_8H_{19}C_2H_3O_2+KCl.$

It may be considered as an acetic ether, in which the residue SiC_8H_{19} plays the part of monoatomic radical $\left.\begin{matrix}SiC_8H_{19}\\C_2H_3O\end{matrix}\right\}O.$ At first the method of purification with sulphuric acid was not employed and the range of temperature at which the ether distilled was larger. The following analyses were made of such products:

I. *Boiling-point*=200°–210°—*Substance*=0·2225 *grms.;* CO_2= 0·4845 *grms.;* H_2O=0·2278 *grms.*
II. *Boiling-point*=209°–215°—*Substance*=0·2743 *grms.;* CO_2= 0·5900 *grms.;* H_2O=0·2755 *grms.*
III. *Boiling-point*=215°–225°—*Substance*=0·2940 *grms.;* CO_2= 0·6385 *grms.;* H_2O=0·3100 *grms.*
IV. *Boiling-point*=219°–224°—*Substance*=0·2013 *grms.;* CO_2= 0·4335 *grms.;* H_2O=0·2115 *grms.*

	I.	II.	III.	IV.	Calculated for $SiC_8H_{19}C_2H_3O_2$.
C=	59·38	58·66	59·23	58·73	59·40
H=	11·37	11·15	11·71	11·67	10·89

After the treatment with sulphuric acid a perfectly pure product was obtained.

I. *Boiling-point* =208°–214°—*Substance*=0·2190 *grms.;* CO_2= 0·4790 *grms.;* H_2O=0·2210 *grms.*
II. *Boiling-point* =209°–210°—*Substance*=0·2540 *grms.;* CO_2= 0·5560 *grms.;* H_2O=0·2580 *grms.*

I.	II.	Calculated for $SiC_8H_{19}C_2H_3O_2$.
59·65	59·69	59·40
11·21	11·28	10·89

The results of an elementary analysis are not very decisive of the purity of a compound of this nature, and the best means of obtaining the true composition of the ether of an acid is afforded by its saponification with caustic potash.

Our ether proved to be so stable, that its saponification could not be completely effected by heating it to 180° with an aqueous solution of potash, but it can readily be accomplished by heating to 120°–130° with an alcoholic solution of caustic potash.

I. 0·5954 grms. of the ether were sealed in a tube with four grms. of an alcoholic solution of caustic potash and with an additional quantity of alcohol. The saponification was effected by heating the tube to 130°. Four grms. of the potash solution required for neutralization 10·8 c.c. of a solution of sulphuric acid, containing 0·1118 grms. H_2SO_4 per cubic centimeter. The contents of the tube, after the potash had been partially neutralized by the acetic acid derived from the saponification of the ether, only required 8·6 c.c. of the sulphuric acid solution for complete neutralization; consequently the quantity of acetic acid present in the ether corresponded to 2·2 c.c. of the sulphuric acid solution. According to calculation it should have been 2·6 c.c. In order to prove that acetate of potassium had really been formed, the neutralized solution was evaporated on a water-bath, and the dry residue was treated with absolute alcohol. Acetate of potassium was dissolved by the alcohol, and could be easily recognized on evaporating the solution.

The other product formed during the saponification must be an alcohol of silicic ethyd containing the same radical as the above mentioned acetic ether, and, on repeating the experiment with a considerable quantity of substance, we succeeded without difficulty, on treating with water the alcoholic solution after saponification, in obtaining such a compound. The alcohol of silicic ethyd is a liquid lighter than water, and insoluble in it, and boiling at about 190°. Its formula is $SiC_8H_{19}OH$.

I. *Substance incompletely purified distilled* 185°–190°. *Substance* =0·1477 *grms.; CO_2=*0·3200 *grms.; H_2O=*0·1667 *grms.*

II. *Purified substance boiling* 185°–195° — *Substance*=0·2100 *grms.; CO_2=*0·4600 *grms.; H_2O=*0·2355 *grms.*

III. *Same substance*=0·1970 *grms.; CO_2=*0·4320 *grms.; H_2O=* 0·2210 *grms.*

	I.	II.	III.	Calculated for $SiC_8H_{19}OH$
C=	59·08	59·74	59·80	60·00
H=	12·54	12·46	12·46	12·50

The properties of this body, so far as we have studied them, are entirely similar to those of the alcohols of the ordinary series, which contain a large number of atoms of carbon.

We have already shown that it forms an ether with acetic acid; it also forms an alcoholate of sodium, dissolving that metal with disengagement of hydrogen to form a gelatinous mass, which regenerates the alcohol and gives a solution of caustic soda, when it is treated with water.

It is apparent, from the facts above cited, that, in a certain class of reactions, the group of atoms, SiC_8H_{19}, remains intact, and plays the part of a compound radical, in the same way that the ordinary alcoholic radicals, like ethyl, (C_2H_5), and amyl, (C_5H_{11}), remain undecomposed in the same class of reactions. The new body, in its relations to many reagents, is simply a new hydrocarbon, with silicon substituted for a portion of the carbon.

It is most remarkable that the presence of silicon in the hydrocarbon modifies its properties to so slight a degree: in fact we have considered silicic ethyd as belonging to the same class of bodies as the petroleum oils, and have applied to it the same methods of study which have been used so successfully by Pélouze and Cahours* in treating the American petroleums, and have obtained similar results. The want of the necessary material has prevented us from completing the study of the alcohol, but we hope to take up the research again.

We may embody this idea of the theory of the constitution of silicic ethyd, and recall its analogy with a well known class of hydrocarbons, by naming it the *hydrid of silico-nonyl.* The alcohol is *silico-nonylic alcohol* containing the radical silico-nonyl (SiC_8H_{19}).

Hydrid of nonyl, (C_9H_{20}), of which the silicic compound may be regarded as a product of substitution of silicon for one atom of carbon, should be obtained by the action of zinc-ethyd on the chlorid of carbon—$CCl_4 + 2Zn(C_2H_5)_2 = 2ZnCl_2 + [C(C_2H_5)_4 = C_9H_{20}]$, and we have made some experiments with a view to preparing it in this way. Thus far, however, we have failed to obtain the reaction with chlorid of carbon and zinc ethyl alone, and also with zinc ethyl to which sodium has been added.

Friedel and Ladenburg† have obtained a hydrocarbon by the action of zinc ethyd upon methyl-chloracetal, whose composition is represented by the formula $C(CH_3)_2(C_2H_5)_2$, and which must be regarded as analogous in constitution and mode of formation with the body, which we sought to obtain from the chlorid of carbon, so that the production of the latter may be considered as probable.

We have noticed, while studying the bromated products of substitution of silicic ethyd, that in them the residue SiC_8H_{19} combined with the bromine does not act like an alcoholic radical, but that, when they are brought in contact with acetate of potassium, or with caustic potash, the atom of ethyl containing the bromine is separated from it and replaced by oxygen, to form the oxyd of silicic triethyd; the same is true of the chlorated compounds, which contain more than a single atom of

* Comptes Rendus de l'Académie des Sciences, lvi, p. 565, 1863.

† Comptes Rendus de l'Académie des Sciences, lxiii, p. 1083, and Bulletin de la Société Chimique, [2], vii, p. 65.

chlorine, and here the presence of silicon reveals itself in the hydrocarbon, determining a point of weaker cohesion, which results in the rupture of the union between itself and the carbon of the atom of ethyl containing the chlorine. In these last mentioned reactions, therefore, an analogy is apparent between silicic ethyd, and the other known compounds of organic radicals with metals.

The chlorated silicic ethyd, whose boiling point was 210°–220°, was experimented upon, and the body was heated with an excess of acetate of potassium in alcoholic solution. On opening the tubes we found that the same gas was given off in greater abundance, whose production we have already noticed from the higher chlorated compounds which approach the monochlorated compound more nearly in their composition. In one operation we observed that the gas, which was first evolved, contained chlorine, and could be absorbed by bromine; this was not the case with the gas given off afterwards.

In another operation, in order to obtain a clue to the reaction, we passed the gas into a solution of subchlorid of copper in ammonia, and then into bromine. A small quantity of the cupric compound of acetylene and of the bromid of ethylene, or of chlorated ethylene, was formed.

The principal product of the reaction was the same oxyd of silicic triethyd, which was produced by the action of acetate of potassium on the bromated silicic ethyd.

This product was treated as before, with sulphuric acid to purify it, and the following analysis was made of it:

I. *Substance*=0·2210 *grms.*; CO_2=0·4745 *grms.*; H_2O=0·2460 *grms.*

	I.	Calculated for $O\left\{\begin{matrix}Si(C_2H_5)_3\\Si(C_2H_5)_3\end{matrix}\right.$
C	58·55	58·53
H	12·36	12·19

It is possible that the formation of this compound may be represented by the equation:

$$2Si(C_2H_5)_3C_2H_3Cl_2+2KC_2H_3O_2=2KCl+O(C_2H_3O)_2+$$
$$2C_2H_3Cl+O\left\{\begin{matrix}Si(C_2H_5)_3\\Si(C_2H_5)_3\end{matrix}\right.$$

The formation of acetylene may be due to the action of chlorated ethylene upon the acetate of potassium, according to the equation:

$$C_2H_3Cl+K\ C_2H_3O_2=HC_2H_3O_2+KCl+C_2H_2.$$

This interpretation of the reaction can not be considered as established without further verification; but one fact is unquestionable, and appears to us very important, namely: that it is an atom of ethyl containing two or more atoms of chlorine, which separates from the silicic ethyd to give rise to the oxyd, and consequently the continued substitution of chlorine for hydrogen takes place in an atom of ethyl already containing chlorine, and not as might have been expected in an atom of ethyl, which contained no chlorine already. The fact is contrary to our usual ideas, founded upon the electro-chemical theory in regard to chemical affinity, and its significance in the study of organic radicals is easily appreciated. According to the theory, a group of atoms, already containing chlorine, should be less inclined to receive a further amount, and the substitution should take place by preference in the atoms of ethyl which are free from chlorine.

The observation which we have made is not without analogy, for Lieben* has shown that, in the action of chlorine upon ordinary ether, the substitution of two atoms of chlorine takes place in one of the atoms of ethyl to form the body, $\left.\begin{matrix}C_2H_3Cl_2\\C_2H_5\end{matrix}\right\}O$, while the other atom of ethyl remains unacted upon. It is remarkable that this analogy should exist between ether and silicic ethyd, a body resembling a hydrocarbon so much more clearly than ether does.

Oxydation of Silicic Ethyd.

We have already stated that silicic ethyd is a very stable compound, and that in order to oxydize it completely with strong nitric acid or with a mixture of chlorhydric acid and chlorate of potassium, it is necessary to operate at a temperature of 180°. We endeavored to obtain a partial oxydation by heating with fuming nitric acid at a lower temperature, and for this purpose an apparatus was made entirely of glass, in which the silicic ethyd was boiled with the nitric acid, and the vapors were condensed and made to flow back into the vessel which was heated. After prolonged ebullition, during which nitrous fumes were given off, the product was washed with water and treated with ether, in which it was in great part soluble. On evaporating the etheric solution a viscous liquid was obtained, which could not be distilled, but which was dried in vacuo over sulphuric acid and analyzed.

I. *Substance*=0·2275 *grms.*; CO_2=0·3880 *grms.*; H_2O=0·2010 *grms.*

II. *Substance*=0·3205 *grms.*; SiO_2=0·1960 *grms.*

	I.	II.	Calculated for $SiO(C_2H_5)_2$
C=	46·51	----	47·05
H=	9·81	----	9·80
Si=	----	28·53	27·45

* Bulletin de la Société Chimique, II, viii, p. 429, and Annalen der Chem. und Pharm., cxli, p. 236.

These numbers accord very nearly with those required by the composition of an oxyd $SiO(C_2H_5)_2$ in which two atoms of of ethyl are replaced by one atom of oxygen, and the body would be the next more advanced product of oxydation to the oxyd of silicic triethyd, but, as we have not made sufficient experiments to determine the chemical properties of this substance, we are unable to form a decided opinion as to its true nature.

Silicic Methyd.

We first attempted to prepare silicic methyd by means of mercuric methyd and chlorid of silicon. The two bodies were heated together in a sealed tube for 15 hours at 180°–200°; lamellar crystals of mercuric chlorid and methyd (HgC_2H_3Cl) were formed, and a gas which was not absorbable by bromine was given off on opening the tube. The liquid contents of the tube were distilled with caustic potash in order to destroy the chlorid of silicon, and were found to consist chiefly of undecomposed mercuric methyd together with a small quantity of a more volatile body, which seemed to be silicic methyd. This mode of preparation not being advantageous, we had recourse to zinc methyd in the next operation.

The mercuric methyd was transformed into zinc methyd by the process given by Frankland, and the latter was heated with an excess of silicic chlorid for several hours at 200°. A reaction commences at 180°, but a temperature of 200° is necessary to render it complete. The tube contained chlorid of zinc as a white powder, and we were able to obtain from it by distillation a volatile liquid, which, after having been washed with a solution of caustic potash, had the same properties as the silicic methyd obtained with mercuric methyd.

The preparation of zinc methyd by means of the mercuric methyd is tedious and disagreeable, and we therefore preferred to obtain it by the action of zinc upon the iodid of methyl, a method which has been already employed by Butlerow* on a small scale. Instead of the glass tubes which he employed, we used Frankland's digester, in which we heated zinc-turnings at 120° with iodid of methyl, taking the precaution to interrupt the operation from time to time in order to cool the digester with ice-water, and to open it to allow the escape of the gases† which form in large quantity. We obtained in this manner,

* Bulletin de la Société Chimique, v, p. 582.

† Notwithstanding Mr. Butlerow's assertion (Annalen der Chem. und Pharm., cxliv, p. 39), that the zinc methyl gases are not poisonous, one of us has repeatedly experienced ill effects from breathing them, and it is advisable to set them on fire as they issue from the digester. It is possible that the difference between our own observations and those of Mr. Butlerow may be due to impurities in the zinc or to the fact that we used a copper digester.

by distilling directly from the digester, zinc methyd, which still contained a little iodid of methyl. This product was treated in the digester with zinc turnings and chlorid of silicon, after we had assured ourselves that chlorid of silicon does not act upon metallic zinc at the temperature employed, but only upon the zinc methyd which is formed from it. Indeed chlorid of silicon is not decomposed even by sodium except at a high temperature.

In order to allow the zinc to act upon the small quantity of iodid of methyl contained in the zinc methyd, the digester was first heated for 12 hours at 120°, and then for 10 hours at 200° to effect the reaction between the chlorid of silicon and the zinc methyd. The digester was cooled with ice before it was opened. After the escape of the gas the product was distilled into recipients cooled with ice, and then treated at 0° with a solution of caustic potash in order to destroy any excess of chlorid of silicon which might be present. It is important to employ nearly equivalent quantities of zinc methyd and of silicic chlorid, because the heat which is developed by the action of the caustic potash upon the excess of either occasions a loss of the silicic methyd.

Silicic methyd obtained by this process is a clear transparent liquid, lighter than water and boiling at 30°–31°. It burns with a luminous flame and a smoke of silicic acid. The following analyses were made of this substance:

I. *Substance*=0·1855 *grms.*; CO_2=0·3660 *grms.*; H_2O=0·2275 *grms.*

The substance was burnt too quickly in the first analysis and a loss of carbonic acid was occasioned.

II. *Substance*=0·1940 *grms.*; CO_2=0·3875 *grms.*; H_2O=0·2350 *grms.*

I.	II.	Calculated for $Si(CH_3)_4$
C=53·81	54·47	54·54
H=13·63	13·46	13·63

The determination of silicon in this substance presents unusual difficulties, on account of its great stability in contact with oxydizing agents and its volatility. We employed the method, which was used for the silicic ethyd, but here it is necessary to enclose the substance in a bulb which is broken after sealing the tube. (Silicic ethyd boils at so high a temperature, that it can be weighed in a long narrow tube with a cork). Fuming nitric acid was the oxydizing agent used, and the silicic methyd was heated with it for two days at 200°, but was found on opening the tube not to be completely decomposed. In a second determination we used a very large excess of fuming nitric acid and heated for forty hours at 250°–300° and obtained the following result:

Substance=0·2330 *grms.* ; *SiO_2*=0·1405 *grms.*
Si= 29·85 p. c. calculated=31·81.

It is difficult to remove the silicic acid completely from the tube by a treatment with caustic potash, and either there was a loss in manipulation, or the silicic methyd was not completely decomposed even at 300°.

Two other determinations made at a still higher temperature were lost from the bursting of the tubes.

The above analyses leave no doubt that the composition of silicic methyd is represented by the formula: $Si(CH_3)_4$, and this result is completely in accordance with the vapor density determination made by Gay Lussac's method.

Substance employed=0·1813 *grms.*
Temperature of the bath 100°.
Height of the barometer 751·7 *m.m. at* 8°.
Volume occupied by the vapor 85 *c.c.*
Height of the mercury in the measuring tube 194 *m.m.*

Vapor density by experiment	=3·058
Vapor density by calculation	=3·045

If the silicic ethyd represents the hydrid of silico-nonyl, the silicic methyd is the hydrid of silicopentyl, SiC_4H_{12}, or the silicated substitution product of the hydrocarbon of the amylic alcohol series.

The want of material has prevented us from carrying the study of this body farther; we will only call attention to the great difference in the boiling points of theses homologous silicated hydrocarbons.

Silicic ethyd boils at		152°·5	centigrade.
Silicic methyd	"	30°·	"
Difference	=	122°·5	"

This difference corresponds to 30°·5 for each increment of CH_2 and is quite at variance with Kopp's law. This fact is the more remarkable since we have shown that in the homologous silicic ethers of the normal series, the difference of boiling-point corresponding to an increment of CH_2 is 11° and in the disilicic ethers it is only 5°.

Silicic Ethyd and Methyd.

It is obvious that considerable interest attaches to the completion of the series of the silicated hydrocarbons, of which we have described the members corresponding to the pentyl and the nonyl group, and it appears probable that all the intermediate ones may be obtained by the simultaneous action of zinc methyd and zinc ethyd, in different proportions upon the chlorid of silicon; we have not yet, however, been able to make any extended researches in this direction, but will give the result of a single experiment conducted on a small scale.

In order to prepare a mixture of zinc methyd and zinc ethyd, we heated in the digester for 24 hours at 100°, a mixture of iodid of methyl and of iodid of ethyl with zinc turnings. The liquid after distillation was found to contain iodine, and it was reheated for 48 hours with the pulverized alloy of zinc and sodium and with zinc turnings; we thus obtained 35 grms. of a product, whose boiling-point was lower than that of zinc ethyd. To this product 8 grms. of zinc methyd were added and 85 grms. of the chlorid of silicon, and the whole was heated for seven hours at 195°. The resulting product was distilled, washed with a solution of caustic potash, and treated with strong sulphuric acid, 10 grms. of a liquid, insoluble in sulphuric acid were obtained, and were submitted to a fractional distillation. The greater part passed at 63°–67°. This portion was analyzed.

I. *Substance*=0·1776 *grms.*; CO_2=0·4240 *grms.*; H_2O=0·2284 *grms.*

	$Si(CH_3)(C_2H_5)_3$	$Si(CH_3)_2(C_2H_5)_2$
C=65·11	64·61	61·20
H=14·28	13·84	13·79

It would appear from the analysis that this body is silicic methyd-tri-ethyd nearly pure, but its low boiling-point renders this highly improbable, and it is possible that the high percentage of carbon and hydrogen may be due to the presence of some saturated hydrocarbon. According to its boiling-point it should be silicic tri-methyd ethyd, but we had not a sufficient quantity of material to make further experiments in order to determine its true composition. It is certain that the body was neither silicic methyd nor silicic ethyd but an intermediate product.

The bodies studied in this research belong to the same type as chlorid of silicon.

Chlorid of silicon,	$SiCl_4$.
Silicic ethyd,	$Si(C_2H_5)_4$.
Chlorated silicic ethyd or chlorid of silico-nonyl	$Si(C_2H_5)(C_2H_4Cl)$.
Acetate of silico-nonyl,	$Si(C_2H_5)_3(C_2H_4C_2H_3O_2)$.
Silico-nonylic alcohol,	$Si(C_2H_5)_3(C_2H_4OH)$.
Dichlorated silicic ethyd,	$Si(C_2H_5)_3(C_2H_3Cl_2)$.

Except the oxyd which has a strong tendency to form in so many reactions, and which belongs to a different type: namely, to one in which two groups of molecules are linked together through the medium of oxygen. It may be referred to the same type as the disilicic ethers.

Disilicic hexethylic ether, $O \begin{cases} Si(C_2H_5O)_3 \\ Si(C_2H_5O)_3 \end{cases}$

Oxyd of silicic tri-ethyd, $O \begin{cases} Si(C_2H_5)_3 \\ Si(C_2H_5)_3 \end{cases}$

The oxychlorid of silicon, $O \begin{cases} SiCl_3 \\ SiCl_3 \end{cases}$

belongs also to the same type.

In some of these compounds the chlorine is represented as combined with carbon in the place of hydrogen, and in others as combined directly with silicon. The difference in formulas is justified by the marked difference in properties which the chlorine exhibits in the two kinds of combination.

Compounds containing chlorine combined directly with silicon are readily decomposed by water with formation of chlorhydric acid; while the chlorine in the other class of compounds displays the same inertness, which characterizes it in hydrocarbons, and is not acted upon by water, and only at a very high temperature by acetate of silver. Exactly the same difference of properties obtains for the radical of acetic acid contained in the acetins of silicic ether, where it is in direct combination with the silicon, and the same radical contained in the acetate of silico-nonyl, where it is in combination with carbon.

Only one point remains in which the analogy between silicon and carbon is incomplete. We have said that the most characteristic property of carbon in organic bodies is its power of combining directly with itself to form a complex molecule, capable of combining still farther with other elements, as when two atoms of carbon, C_2, combine with six atoms of hydrogen to form the hydrid of ethyl, C_2H_6. All the bodies thus far discussed belong to the simplest type of carbon compounds, as CH_4 and its analogue SiH_4; and in silicic ethyd 4 times C_2H_5 occupy the place of H_4; but Friedel and Landenburg* have lately completed the analogy and obtained the body, $Si_2(C_2H_5)_6$, belonging to the same type as Si_2H_6 and C_2H_6, showing that even in its quality of forming condensed compounds silicon resembles carbon.

* Comptes Rendus de l'Académie des Sciences, lxviii, p. 920, 1869.

ART. XXXIII.—*Description and Analysis of the Franklin County Meteoric Iron; with remarks on the presence of Copper and Nickel in meteoric irons; the method of analyzing the same; and the probability of the Lead in the Tarapaca iron having been originally foreign to that mass;* by J. LAWRENCE SMITH, Louisville, Ky.

1. *The Franklin County Meteoric Iron.*

THE Franklin County meteoric iron was first brought to my attention in a blacksmith shop in Frankfort, Kentucky. It was carried there to be tested in regard to its quality as iron; being supposed by its discoverer to indicate an iron mine. Mr. Nelson Alley became possessed of it, and kindly presented it to me.

It came from a hill eight miles southwest of Frankfort, lat. 38° 14′, long. 80° 40′ (Greenwich), and was discovered in 1866. It passed into my possession in 1867, and was then described by me, but the manuscript was lost after its leaving my hands, and the original notes were displaced; the notes have been recently discovered and the iron again analyzed.

Its form is somewhat globular, with a highly crystalline structure. Its weight was twenty-four pounds, and this appears to have been its original weight, only a few flakes having become detached by the rusting through of some of the fissures —sp. grav. 7·692.

Its composition when perfectly freed from rust and earth is

Iron,	90·58
Nickel,	8·53
Cobalt,	0·36
Copper,	minute quantity
Phosphorus,	0·05
	99·52

Having, as it will be seen, the usual composition of meteoric irons.

While on the subject of this iron, I will add some remarks.

2. *On the presence of Cobalt in Meteoric Irons.*

My attention has been directed again and again to meteoric irons, whose analyses are given without mention of the presence of cobalt, and in some instances, with the distinct statement that it is absent, as in the recent examination of a meteoric iron from Auburn, Macon county, Alabama, by Professor Shepard, who states that "neither cobalt, tin nor copper was detected in this iron." I cannot but suggest the importance of making a most critical examination of these irons before pronouncing this fact; for in every analysis that I have made of meteoric irons, (over one hundred different specimens), with this in view, cobalt has been invariably found, along with a minute quantity of copper. A great many of the analyses made were of irons that had been previously examined without a recognition of the cobalt.

The presence of these ingredients, even in small quantities, is a matter of considerable mineralogical interest, as is the case of the presence of small quantities of other elements in many minerals; a fact that I will have occasion to refer to at some future time, in connection with leucite and other silicates.

As a guide to those who may wish to know the manner of my examination of meteoric iron, I will give a little in detail the method adopted in separating the metals.

Method of analysis.—A small piece of the iron is selected, perfectly free from crust and earthy matter. I sometimes plunge the fragment into nitric acid, somewhat diluted, warm the acid and continue the action for a few seconds, withdraw the iron, wash well and dry it. The piece selected for analysis should be about one gram, or a little over, (except where the copper is sought for quantitatively, and then at least ten grams should be used for the copper estimate alone). Treat the iron in a porcelain capsule, or glass flask, with a mixture of hydrochloric and nitric acids, consisting of four parts of the former to one of the latter, and about as much water as acid; dissolve over a water-bath; if a capsule be used, invert a funnel over the mixture, the edges of the funnel entering the capsule, but not touching the mixture. Continue the action on the water-bath until the solution is complete, evaporate to dryness (having washed what may adhere to the inner surface of the funnel into the capsule), then add a little more hydrochloric acid and evaporate again nearly to dryness; this is done to insure driving off the last portion of nitric acid, and rendering the iron easily soluble. Add to the contents of the capsule an ounce or two of water, and, if there be a residue, it must be collected on a weighed filter, dried, weighed, and reserved for future examination; if the quantity be too small for examination, a larger portion of the iron must be examined with special reference to this residue—which most commonly is a silicate, but may contain carbon or chromic iron (chromite).

If, however, there is no residue, proceed to the next step at once without filtering; if the solution has been filtered, the following steps are the same. Examine first for sulphur. This is done by adding a few drops of chlorid of barium; if there is a precipitate, it is collected on a filter, and the sulphate of baryta obtained furnishes the amount of sulphur present. Next pass a stream of sulphuretted hydrogen through the filtrate to complete saturation, previously adding a drop or two of sulphuric acid; much sulphur will be deposited and a very minute quantity of copper (not traceable by the color of the precipitate, but only recognized by the most delicate tests after the sulphur of the collected precipitate is burnt away); the solution, thrown on a filter, leaves the precipitated sulphur, the little trace of copper, and all the excess of the baryta that had been added, if the excess had been slight. The filter is then ignited in a porcelain crucible—the residue treated with a few drops of nitric and sulphuric acids, which suffices to dissolve the copper, and when evaporated to dryness leaves the copper in the form of sulphate, slightly acid, as there is no necessity of heating so high as to drive off the very last trace of sulphuric acid. The presence of the trace of copper is easily shown by adding a drop or two of water to dissolve the sulphate, and with the end of a glass rod, placing a little of the solution on a clean and bright surface of iron, as the blade of a knife, for instance. In no examination of a meteoric iron have I failed to detect copper by this means.

When more iron is used, and there is consequently more copper, it can be separated and weighed. Tin and lead will also be found in the precipitate, if they be present, but I have never detected either, except lead in the case of the Tarapaca iron, which I have every reason to believe was originally foreign to the iron.

The sulphuretted hydrogen precipitate, which I have always obtained, is so minute in a gram of iron that it may be dispensed with, and the iron, nickel and cobalt be separated, which is accomplished as described a little farther on. If, however, sulphuretted hydrogen has been used, the iron in solution is in the form of protoxyd, and must be converted into the peroxyd, which is accomplished by adding a little chlorate of potash and hydrochloric acid that have been made to react on each other by heating, before adding it to the boiling solution of iron, &c.

The solution of iron should have a bulk of ten or twelve ounces; to it is added a solution of carbonate of soda in sufficient quantity to nearly neutralize the free acid; the iron is now precipitated by acetate of soda, with all the well known precautions. I wash this precipitate only partially, and detach it from the filter by washing it into a beaker, and re-dissolving it by hydrochloric acid, and precipitate it a second time by acetate of soda; I then subject it to complete washing, and estimate the iron in the way usually employed. This second precipitation is necessary to separate an appreciable quantity of nickel remaining in the acetate of iron after the first precipitation; and after considerable experience, I must say that it is the only method of separating, with any degree of accuracy, iron from nickel.

The solution separated from the iron, and containing nickel and cobalt, is concentrated down to four or five ounces, then treated with caustic potash or soda, thrown on a filter, and washed with hot water, with all the usual precautions when nickel is precipitated by an alkali. The precipitate is dried, ignited and weighed; after which it is dissolved in nitric acid over a water-bath, and the acid solution evaporated nearly to dryness; about two or three drams of water are added, then a concentrated solution of nitrite of potash, then an excess of acetic acid; this is now set aside for forty-eight hours, during which time the nitrite of cobalt is completely separated; it is next thrown on a filter, washed and estimated in the manner proposed by the author of this method; I usually employ a concentrated solution of the sulphate of potash to wash with. This method, to say the least of it, has in my experience proved fully equal to the cyanid method, and is much more simple; and by it I have never failed to detect and estimate cobalt in every meteoric iron that has come under my examination.

In examining for *phosphorus*, the following method is adopted: To three or more grams of the iron in a porcelain capsule, add nitric acid diluted with water; then invert a funnel over the mixture, to protect from loss during the action, evaporate to dryness over a water-bath, and then on a sand-bath to a temperature of 500° or 600°; the iron is thus converted into an oxyd with little or no nitric acid remaining, and the phosphorus is transformed into phosphoric acid that is now combined with oxyd of iron. The residue is detached as thoroughly as possible from the capsule, and mixed with twice its weight of carbonate of soda, or, better still, with a mixture of carbonates of soda and potash; a little carbonate of soda added to the capsule, and rubbed with a pestle, detaches the last portion of oxyd of iron, or rather leaves so small an amount as to make no error in the future steps of an analysis where the original quantity of phosphorus is so small.

The mixture of oxyd of iron and phosphate is now to be heated in a platinum crucible to the point of fusion of the carbonates for about twenty minutes; then heat the mass with water, when the excess of carbonates will be dissolved, and what phosphate may have been formed; the phosphates will represent all the phosphorus in the iron. Now neutralize the carbonate with hydrochloric acid, and estimate the phosphorus in the ordinary way, by a magnesia salt.

With regard to the detection of chromium, and other special constituents of some meteoric irons, especially those containing some siliceous minerals intimately mixed in the iron, it is not the province of this paper to discuss.

3. *Lead in Meteoric Irons.*

The only instance of the finding of lead in meteoric irons is that of the Tarapaca iron, found in 1840, in Chili, which was examined by Mr. Greg; the metallic lead was detected by him in small masses of varied dimensions.

I have examined several specimens cut from the original mass of iron, two of which are in my possession, and my conviction is, that the metallic lead was altogether foreign to the iron when it originally fell, and has been doubtless derived from lead with which the mass was probably treated by the original discoverers for the purpose of extracting some precious metal, they being ignorant of its true nature. My reasons for coming to this conclusion are, that the lead is found in cavities near the surface of the iron, these cavities having channels of more or less size leading to the exterior of the mass; the iron is honey-combed in its character in many places, which is evident to the eye, and is also indicated by its specific gravity 6·5. In pieces of the iron, detached from the interior of the mass and examined with the utmost care by a magnifying glass to see that there is no possible fissure in it, no lead has been found. These pieces are exceedingly difficult to obtain, and can only be had in very small pieces.

The crust of the iron having the most cavities furnishes most lead, and is in some parts covered by a fused yellow crust of oxyd of lead; this last fact has no significance, however, in the present consideration of the matter. Without venturing to insist too sharply on the view here taken, after the careful examination of so distinghished an observer as Mr. Greg, I recommend this view of the subject to those having larger specimens of the iron than myself.

Art. XXXIV.—*Remarks on the alkalies contained in the mineral Leucite;* by J. Lawrence Smith.

In examining recently many of the silicates containing alkalies, my attention has been called to Leucite, and it is on that mineral especially that I would now remark, reserving for another time my observations on the other silicates.

The specimens of leucite examined came from four localities, Vesuvius, Andernach, Borghetta, and Frescati. They were about as good specimens as are obtained from those localities, although all of them were not equally pure. The alkalies found in each calculated as potash were—

Vesuvius,	21·85
Andernach,	20·06
Borghetta,	20·68
Frescati,	20·38

The specimen from Andernach was analyzed for the silica, &c., and found to contain silica 54·75, alumina 23·08, and 1·55 of oxyd of iron; this last seemed to be mechanically disseminated through the crystals.

I say above in relation to the alkalies "all calculated as potash," for the reason that there is a notable quantity of rubidium and cæsium present in all the specimens above mentioned. In fact, by the method adopted in testing for these alkalies abundant indications are obtained of the presence of rubidium, cæsium (the last not so readily), even when operating on but half a gram of the mineral. I am now engaged in working out a method of estimating quantitatively rubidium and cæsium in the presence of other alkalies; by this method, not yet perfected, the quantity of these alkalies in leucite is found to be about $\frac{9}{10}$ of one per cent of the entire mineral.

Of course it is not at all remarkable that the potash in the different specimens of leucite should be the same; but it is a matter of interest to know that, from whatsoever locality it comes, this minute quantity of rubidium and cæsium occurs with it. On some future occasion I hope to be able to bring together certain generalities in this connection of more or less interest to mineralogists.

I have also detected rubidium in half a gram of margarodite and Warwick mica, and have failed to detect it in apophyllite, thomsonite, pectolite, elæolite, chesterlite, cancrinite and other silicates.

Art. XXXV.—*Examination of a new and extraordinary Gas Well in the State of New York;* by Professor Henry Wurtz.

[Read to the New York Lyceum of Natural History, March 14, 1870.]

A new and copious outburst of gas has recently been observed in the township of West Bloomfield, county of Ontario, and State of New York, about twenty miles south of Rochester, and sixteen miles west of Canandaigua.

It is now about four years since the owner of the ground, Mr. Beebe, while boring with the hope of getting petroleum, struck the cavity from which the gas flows, at a depth, as he states, of 500 feet. The bore-hole is tubed down to, and into, the solid rock, and the tube stands about ten feet above the surface. This tube is five inches in diameter; and the issuing gas, when *burning*, as it was when I saw it, gives in a still atmosphere a flame some thirty feet in height. The flow has been stated independently by two parties, who have measured it with large balloons of known capacity attached to the outlet, to be from four to five feet per second, equivalent to from 15,000 to 18,000 feet per hour, or, in the mean, at the rate of about 400,000 cubic feet of gas per day. From observation on the spot, without any means of exact measurement, however, I am prepared to believe the probability of this enormous evolution of combustible gas from the bowels of the rocks. Such a flow really corresponds to a pressure of but a few feet of water. Ten inches should, according to calculation, drive through a pipe 500 feet long and five inches in diameter 22,000 feet per hour of gas, of the density which I have found for this, namely, 0·7. There is, however, here an important residual projectile force, in addition to this. This flow has now gone on for more than four years, and according to the testimony of residents of the vicinity, without any perceptible diminution of energy; indicating, in the aggregate, an escape of some 600,000,000 of feet, about half the yearly make of our largest gas manufacturing company, the Manhattan. The most remarkable feature is the absence of diminution of flow for so long a time,in connection with the low pressure indicated. I hence infer the probability of an indefinite continuance; as the gas must originate not from a reservoir in a state of compression, but from huge masses or surfaces of rock, from which it oozes out gradually at every pore. This inference is justified from the phenomena of other fountains of natural gas, of which so many are known to have flowed from time immemorial without exhaustion. As to the geological age of the bed from which this gas comes, I was told that Professor Hall, having been consulted, considers it to be most probably the Marcellus shale; and on consultation with Dr. R. P. Stevens, whose acquaintance with both the geology and topography of this section is minute, I find him to agree that a bore-hole 500 feet deep, in this locality, would be very likely to terminate in the Marcellus, the beds of which are here probably a hundred feet in thickness. The outcrops of the Genesee slate (which cross to the southward of this locality, its horizon being some twelve hundred feet higher than that of the Marcellus) also emit combustible gas copiously in places. I cannot dwell at this time, however, on the geological question, but must pass to the chemical examinations. These are still in progress, but much that has interesting has nevertheless been developed.

The points, which I attempted to determine on the ground, though with very imperfect means, were the temperature with which it issues, the photometric power (which is quite appreciable), and the effect of intense cold upon the latter.

The temperature.—A small hollow semi-cylinder of wood, closed at the bottom, was cemented with beeswax against the side of the well-tube near the ground, filled with quicksilver, and the thermometer inserted. It was found, however, that the temperature was not constant, showing a heating of the iron by radiation and conduction from the flame above. At one time, however, the temperature sunk to 59° F., so that the true temperature is below this, it may be as low as 50°; very low for a depth of 500 feet. Doubtless the gas is cooled by expansion from a state of compression. (A curious suggestion occurs here regarding causes of irregularity in increase of temperature in descent in some fossiliferous rocks.)

The candle power was determined with a standard candle by contriving a small dark room with a large blanket shawl, using of course the Rumford or shadow test. The gas was burned from a five-foot steatite-tip bats-wing burner, being first passed through a glass tube so stuffed with cotton as to reduce the pressure just to that which gave the maximum of light. The result was about *six candles.* I had not with me an Argand burner, which, especially if with a very contracted throat, would doubtless afford with this gas a considerably higher candle power. It is well known that the effect of carbonic acid in diminishing illuminating power is very far less in the Argand than in flat flame burners.

The condensation test was made by immersing in snow and salt, in a common water bucket, some sixty feet of small india rubber tubing that I had with me. The thermometer stood at 8° F. in the mixture. No change of the candle power occurred during half an hour, and hence the light-giving hydrocarbons present seem to be permanent gases, or at least practically incondensable. Lime-water showed carbonic acid to be largely present.

Samples were taken for analysis in accurately-ground glass-stoppered bottles, with which, and some quicksilver, I had provided myself. These bottles were stopped under quicksilver, the stoppers having been previously smeared with some thick glycerine. These bottles were then carried to the laboratory of the Manhattan Gas Light Co., in this city, and some analyses made; new methods and manipulations being used which were devised by myself, in conjunction with Professor Silliman, and which we have not yet published.

Results of the analyses.

Marsh gas	82·41
Carbonic acid	10·11
Nitrogen	4·31
Oxygen	0·23
Illuminating hydrocarbons,	2·94
	100·00
Density,	0·693

Another density determination gave a considerably higher figure; but, wishing not to exhaust all my material, I have not repeated it, but have adopted 0·7. Calculation gives 0·7043, assuming the three volumes of unknown illuminants to have a density of 1·5.

With regard to these three volumes per cent of illuminant hydrocarbons; as they are absorbed by Nordhausen acid they cannot belong to the saturated hydrocarbons $C_{2n}H_{2n+2}$, and cannot therefore be hydruret of ethylene $C_4H_4H_2$, as found recently according to Fouque and Gorceix in the gases of the Appenines; in most cases in traces only, but in one case to the extent of nearly 18 per cent! (See *Comptes Rendus*, lxix, 946). This seems at first glance in accord with the opinion put forth by Fouque, founded, as he says, on the study of the gases from American petroleum wells, that the gases of the series $C_{2n}H_{2n+2}$ are especially characteristic of sources of petroleum; but as the almost universal *marsh gas* is itself of this series, I cannot see how any such generalization can be accepted. I am still engaged in further examinations of these hydrocarbon constituents, but my material is at present insufficient.

The 1-400th volume of free *oxygen* found is *really present*, as I am convinced, in the gas as it issues, and is not accidental, as Fouque and other analysts have deemed the traces of oxygen they find in such gases. The extreme precautions taken by me, both in collection and transportation, as well as in analysis, make me confident of this; but as important chemical and geological conclusions are here involved I shall make further and repeated tests of this point.

ART. XXXVI.—*On Flame Temperatures, in their relations to Composition and Luminosity;* by B. SILLIMAN and HENRY WURTZ. FIRST PART.

Read to the American Association at Salem, August, 1869.

1. *Calorific powers or effects of gases.*—The calorific powers or effects of gases lie, in our belief, at the very basis of the true theory of the phenomena of luminiferous gases, and have practical bearings that can scarcely be overrated. In fact, our studies of the subject have led us in the direction of the general conclusion that, all other conditions being equal, the *temperature*, in a given flame, is the main factor of luminosity. This, however, may as yet be regarded merely as a hypothesis; in consequence of the imperfection of our present means of actual experimental demonstration of the temperatures of flames. It is a hypothesis, nevertheless, which is in general

accordance with known facts. By the spectroscope, for example, which can recognize only luminous rays, we find that the higher the temperature the greater the number of these luminous rays. The recent results of Frankland upon the development of luminosity by increased pressure, in flames which are non-luminous under atmospheric pressure, are in accordance with this view; increase of temperature necessarily following increase of pressure.

Very vague views have been rife, even among chemists, with regard to the temperatures of luminiferous flames. Some have been satisfied with believing crude hypotheses; such as that the heat-power of a flame is always proportional to the *density* of the gas or vapor undergoing combustion; or that it is proportional to the *amount of oxygen consumed* by a given volume of the gas; and so on. This latter hypothesis has been one of very common acceptation. A view which is even now entertained by some skilful chemists (than which, however, nothing, as will be shown, could be more fallacious) is, that those individual gaseous compounds, which impart the highest luminosity under ordinary conditions, are also the most productive of heat.

The admirable researches of Bunsen, of Heidelberg, placed in our possession some years ago the means of computing, at least with approximate accuracy, the heat of flames of gases of known composition. Few however have properly and successfully applied Bunsen's methods in practice. We consider it quite time that these methods should be introduced to the knowledge of gas engineers, in forms available to them.

Bunsen's formulæ for these computations are based upon the actual experimental determinations of the *total* amounts of heat developed by the combustion of different pure combustible gases with pure oxygen, made by Favre and Silbermann; and upon Regnault's determinations of the specific heats of gaseous products of combustion.

It is not to be maintained that Favre and Silbermann's numbers are strictly correct, but they are doubtless approximate, and at least proportionally correct among themselves. At any rate, they are the best data we have. Those employed here are included in the following table. They are usually given in the text-books for equal *weights* of the gases, but we have reduced them to the standard of equal *volumes* also, as more suitable to our present purpose. This reduction is made simply by multiplying the equivalents for weights, by the densities as given in the third column.

TABLE I.

	Total calorific equivalents. Of equal weights.	Of equal volumes.	Densities Hydrogen = 1.
Carbonic oxyd	34,462° C.	34,462° C.	1
Hydrogen	2,403°	33,642°	14
Marsh gas	13,063°	104,504°	8
Olefiant gas	11,858°	166,012°	14

The meaning of this table is simply that equal weights of water would be heated by the several gases to temperatures proportional to the numbers in the first column, when equal *weights* of the gases are burned; and proportional to those in the second column, when equal *volumes* are burned.

A cursory glance at the figures in the second column of this table might seem to justify the notion, hitherto entertained by many, of the comparatively low calorific powers of hydrogen and carbonic oxyd; and it was doubtless as a consequence of such a comparison as this, that statements have been put forth and widely accepted among American gas engineers to the effect, that the weight of water heated from the freezing to the boiling point by one cubic foot of the four main components of illuminating gas, respectively, is as follows:

Hydrogen	2·22	lbs.	water.
Carbonic oxyd	2·16	"	"
Marsh gas	6·17	"	"
Olefiant gas	10·74	"	"

The figures here being obviously about in the same ratio as those in the second column of Table I. Several most grave errors, however, are here involved. To get at the true relative calorific effects of the above gases, when burned in the open air, in heating water below its boiling point, deductions must be made, not only for the specific heats of the products of combustion of the gas, but also, more important still, for the specific heat of the nitrogen of the air required to burn the gas. In fact, when we consider that for each volume of oxygen required to burn a given volume of a gas, about four volumes of nitrogen must be heated up to the temperatures of the flame, it becomes easy to conceive, what is actually the fact, that within certain limits the waste of heat due to this cause alone counterbalances altogether the advantage that would be supposed to result from the crowding of combustible matter into so condensed a form as in the illuminating hydrocarbons. The result of our investigations of this matter is that the heating powers of the flames of pure hydrogen and pure olefiant gas, even when used to the greatest advantage, to heat water below its boiling point, are almost or quite identical.

In this discussion we have occasion to use the numbers representing the specific heats of but three gases, the three, namely, which remain after complete combustion, *steam*, *carbonic acid* and *nitrogen*; as we must assume that in the hottest and most luminous zone or shell of the flame, there is no oxygen in excess to be heated. These three numbers are, according to Regnault's latest determinations, for equal weights of

Steam	0·4805
Carbonic acid	0·2163
Nitrogen	0·2438
(*Liquid water* being	1·0000)

This means that the amounts of heat which would raise one pound of water and steam *to the same degree* are in the ratio of 0·4805 for the pound of steam, and 1 for the pound of water.

2. *Calculation of the calorific effects of Hydrogen burning in air.*—Let us take, first, the simplest case possible, that of hydrogen with exactly the right admixture of pure oxygen to burn it, which, by Table I, develops a total heat of 34462° C.; that is, would heat a certain weight of *liquid* water to this temperature. In order to find the actual amount of heat contained in the products of combustion, we must first take into account the fact that one pound of hydrogen burns to *nine pounds* of steam, and then obtain the ratio between the above number, 34462, and the amount of heat necessary to heat nine times the weight of steam; that is, nine times the specific heat of steam. Calling the total residual heat in the produced steam x, we have the simple proportion:

$$9\times(\text{sp. heat of steam}=0{\cdot}4805):34462^\circ::(\text{sp. heat of water}=1):x$$

$$\text{or, } x=\frac{34462^\circ}{4{\cdot}3245}=7969^\circ\text{ C.*}=14376^\circ\text{ F.};$$

a number which, we may add, represents the *maximum* of heat capable of being imparted theoretically *to liquid water* by the flame of Hare's oxyhydrogen blow-pipe.

Still, we have by no means here the actual temperature of the free or open flame of Hare's blow-pipe, which is generally lower than this figure; as we have not yet taken into account the latent heat, or heat of vaporization, of the 9 lbs. of steam formed. The Centigrade temperature necessary to convert 1 lb.

* Bunsen, in his Gasometry (English edition of 1857, p. 242), gives this number as 8061° C., the difference being due to his using a different number for the specific heat of steam, namely, 0·475, apparently an earlier determination of Regnault. Bunsen makes here the singular oversight of regarding this figure as the temperature, when "the gases can freely expand, as is the case in an open flame," overlooking the correction necessary in this case for the *latent heat of steam of combustion*, as is explained in the text above. This oversight has doubtless been corrected by the distinguished author, but we have been unable to ascertain where the correction has been published.

of water into steam being 537°; to get the actual temperature of the oxyhydrogen flame, we must modify the above equation, so that

$$x = \frac{34462° - (9 \times 537°)}{4 \cdot 3245} = 6851° \text{ C.} = 12364° \text{ F.};$$

which is the temperature actually possible in the flame of the compound blow-pipe, *were the combustion instantaneous and complete.*

When hydrogen gas burns *in air*, however, as has been before stated, another deduction of enormous amount must be made from the above figures, due to the heat required to expand the nitrogen. This is obtained simply by adding to the divisor, as above, the weight of the nitrogen of the air employed, multiplied by its specific heat. The weight of the nitrogen in air= 3·318 times the oxygen; so that the latter of the above equations becomes

$$x = \frac{34462° - (9 \times 537°)}{4 \cdot 3245 + (8 \times 3 \cdot 318 \times 0 \cdot 2438)} = 2744 \cdot 5° \text{ C.} = 4972° \text{ F.}$$

We have here a full explanation of the extraordinary loss of power in illuminating gas by admixture of air, which we have discussed elsewhere.* The nitrogen of such air is not merely a diluent, or even a mere deductive quantity; its specific heat is an actual *divisory* function in diminishing the flame-temperature.

This, then, is the actual temperature to which the flame of hydrogen gas burning in the atmosphere might attain to, supposing complete and instantaneous combustion. If it is desired to obtain instead, the total calorific effectiveness, as in heating water below its boiling point—in which case the latent heat of the steam of combustion becomes also available—the above expression is changed by simply omitting the subtrahend in the numerator:

$$x = \frac{34462°}{4 \cdot 3245 + 6 \cdot 4714} = 3192° \text{ C.} = 5778° \text{ F.}$$

3. *Calculation of the calorific effect of carbonic oxyd burning in air.*—As the product of combustion is here solely carbonic acid, no latent heat of steam enters, and the calorific effectiveness is the same, under all circumstances, in air. In the numerator we substitute of course the calorific equivalent of one volume of carbonic oxyd from Table I; and in the denominator, for the specific heat of 9 lbs. of water, that of 22 lbs. of carbonic acid, being the weight of the latter formed by the combustion and combination of 14 lbs. of carbonic oxyd, with 8 lbs. of

* This Journal, II, xlviii, 40.

oxygen. The number for the specific heat of nitrogen is the same as before; and the equation is now

$$x = \frac{33642^\circ}{(22 \times 0{\cdot}2163) + 6{\cdot}47 = 11{\cdot}23} = 2996^\circ \text{ C.} = 5425^\circ \text{ F.}$$

4. *Marsh gas and Olefiant gas.*—In these two cases, we have as products of combustion both carbonic acid and water; and, therefore, when the calorific effects are sought for, we have not only the latent heat of steam entering as a subtrahend into the numerator; but also into the denominator, as divisors, all three of the specific heats of steam, carbonic acid, and nitrogen.

Then, as 8 lbs. of marsh gas consume 22 lbs. of oxygen, and produce 22 lbs. of carbonic acid, and 18 lbs. steam; and as 14 lbs. of olefiant gas consume 48 lbs. of oxygen, producing 44 lbs. of carbonic acid, and 18 lbs. of steam, the equations for the calorific powers of their flames in air become—

For marsh gas:

$$x = \frac{104504^\circ - (18{\cdot} \times 537^\circ)}{(18{\cdot} \times {\cdot}4805) + (22{\cdot} \times {\cdot}2163) + (32{\cdot} \times 3{\cdot}318 \times {\cdot}2138)} = 2414^\circ \text{ C.} = 4386^\circ \text{ F.}$$

And for olefiant gas:

$$x = \frac{166012^\circ - (18 \times {\cdot}537^\circ)}{(18{\cdot} \times {\cdot}4805) + (44{\cdot} \times {\cdot}2163) + (48{\cdot} \times 3{\cdot}318 \times {\cdot}2438)} = 2743^\circ \text{ C.} = 4970^\circ \text{ F.}$$

When the deduction for the latent heat of the steam of combustion is not made, the results in these two gases are considerably higher, as will be obvious from mere inspection of the formulæ.

We shall now give, in tabular form, all the results of our calculations of the calorific powers when burning in the air, of the four gases we have to deal with.

TABLE II.

For equal volumes of the gases burning in air.	Calorific effects in heating liquid water.		Calorific effects, above 100° C.	
	Centigrade degrees.	Fahrenheit degrees.	Centigrade degrees.	Fahrenheit degrees.
Hydrogen (sp. heat HO=·4805)	3192°	5778°	2744°	4971°
Hydrogen (sp. heat HO=·4750)	3204°	5799°	2755°	4991°
Hydrogen (mean	3198°	5788°	5749°	4980°
Carbonic oxyd	2996°	5425°	2996°	5425°
Marsh gas, (sp. heat HO=·4805).	2660°	4820°	2414°	4386°
Olefiant gas, " "	2916°	5481°	2743°	4970°

5. *Computation of calorific effects of mixed gases.*—The above table renders simple the calculation of the calorific effects of any given gaseous mixture, whose centesimal composition is known. It is only necessary to obtain the sum of the multiples

of the percentage of each component gas into its calorific capacity, as given in this table, and divide by 100.*

To serve as examples of these modes of computation we here cite, in tabular forms, the results of some analyses of a number of gaseous mixtures, made by us during the winter of 1868–9. [These analytical results, it may be remarked, possess points of novelty and importance. both scientific and practical, which will bring them up again hereafter, in other connections. They are here placed on record.]

Table III, gives the results of two analyses of gaseous mixtures obtained by passing steam *superheated to incandescence* upward through a mass of *anthracite coal* heated to a high degree in a clay retort of a novel construction, according to what is now known as the "Gwynne-Harris," or American Hydrocarbon Gas System. In this table the results are calculated without carbonic acid and sulphuretted hydrogen, which, with traces of nitrogen and sometimes of oxygen, are found in the unpurified anthracite gas.

TABLE III.

	No. 1.	No. 2.	Mean.
Hydrogen	60·43	59·32	59·87
Carbonic oxyd	35·44	37·14	36·29
Marsh gas	4·13	3·54	3·84
	100·00	100·00	100·00

In Table IV, column 1 gives the results of the analysis of the street gas served out at this period by the New Haven Gas Light Company; made from Westmoreland coal enriched with about six per cent of Albertite. Column 2, the mean of four analyses of the completed hydrocarbon gas made by us at Fair Haven during the same time, by combining gas from the same Westmoreland coal (with 10 per cent of Albertite) with about half its volume of the Anthracite gas. Columns 3 and 4 are obtained from 1 and 2 by centesimal reduction, after deduction of the illuminant ingredients, being what we propose to designate as the non-illuminating *substrata* of illuminating gases.

* Prof. Bunsen, in the masterly discussion of the subject presented in his *Gasometry*, not having in view the exact object we propose. has used a train of reasoning and a mode of formulation of some complexity, to follow which requires some little mathematical skill—part of his object having been to construct a formula so general and comprehensive as to cover the direct computation. from any gaseous mixture independently of its special calorific intensity. We have here aimed at so simplifying as to bring the whole subject within the capacity of all. Our above tabulation of the individual gaseous components, as a starting point, seems to us to accomplish this most effectually, so far as illuminating gases are concerned.

TABLE IV.

	(1.) New Haven City Gas.	(2.) Fair Haven Hydrocarbon Gas.	(3.) Substratum of New Haven Gas.	(4.) Substratum of Fair Haven Gas.
Hydrogen	43·58	46·77	46·79	50·27
Carbonic oxyd	2·14	9·56	2·31	10·27
Marsh gas	47·42	36·71	50·90	39·46
Illuminants	6·86	6·96	-----	-----
	100·00	100·00	100·00	100·00

Table V gives the results of the computation, from our formulæ, of the calorific powers of these five gaseous mixtures, for communicating temperatures both above and below that of aqueous ebullition. We should remark that we have here been obliged to regard the volumes of illuminant hydrocarbons as representing olefiant gas solely; both because we have no certain data as to their real nature, and particularly because, if we actually knew, or should assume, the nature of the hydrocarbon vapors present, still we have no experimental calorific equivalents, as we have for olefiant gas, from which to start in such a computation. We have reason to believe nevertheless that the errors thus introduced are not important in amount.

TABLE V.

	Weights of water equally heated below boil'g; by equal volumes.	W'ts of water equally heated above boil'g; by equal volumes.	1st column reduced to N. Haven gas =100.	2d column reduced to New Haven gas =100.
Anthracite gas	3100	2823	104·2	109·2
Substratum of the New Haven street gas	2917	2581	98·1	99·6
Substratum of the Fair Haven hydrocarbon gas	2962	2640	99·6	102·0
New Haven gas; with the illuminants assumed=olefiant	2974	2592	100·0	100·0
Fair Haven gas; with the illuminants assumed=olefiant	2959	2647	99·5	102·1

3. *Conclusions.*—Some of the practical conclusions to which we are led, by the results of the above investigations, are somewhat remarkable, so that we feel diffident regarding them. It is however always safe to follow the leading of truth, however astray she may conduct us from our preconceived notions.

From Table II it is apparent:

1. That of all known gases, the highest calorific effects, under ordinary atmospheric conditions, are obtainable from *carbonic oxyd;* whose calorific value, above 100° C., is about 3000° C.

2. That, in absolute calorific value, below 100° C., in the atmospheric medium, *hydrogen* surpasses its volume of any other gas; giving a temperature of about 3,200° C.

3. That for all modes of application—that is, for producing both high and low temperatures—the total maximum calorific effectiveness of carbonic oxyd is a *constant quantity.**

4. Compound condensed submultiple volumes of hydrogen, like that in marsh gas, have much *less* total calorific value in air than their volume of free hydrogen.

5. Condensed compound submultiple volumes of gaseous carbon, like that in olefiant gas, have no greater total calorific value, in air below 100° C., than their own volume of carbon gas in the form of carbonic oxyd; while above 100° C. their value is even considerably less.

Art. XXXVII.—*On the Laurentian and Huronian Series in Nova Scotia and New Brunswick;* by Henry Youle Hind, M.A.

1. *Introduction.*

The descriptions contained in this paper, so far as they relate to Nova Scotia, are in the main the results of observations during the summers of 1868 and 1869, while making geological surveys for the Nova Scotian government, in the gold districts of Waverley and Sherbrooke. The comparisons with New Brunswick are based on my official Report on the geology of that Province;† and the references to Cape Breton, when not otherwise stated, are from MS. notes of explorations in that Island during 1866.

The object of this paper is to show that two gneissoid series, supposed to be the equivalents of the Huronian and Laurentian of Sir W. E. Logan, are exposed over very large areas in Nova Scotia, the Island of Cape Breton and in New Brunswick.‡

The boundaries of the series have been traced through parts of Halifax, Hauts and Guysborough counties in Nova Scotia. In New Brunswick ‡ numerous narrow belts extending from the

* Metallurgists, especially, will appreciate the suggestive import of the truth, presented under the first and third heads; here enunciated, as we think. for the first time. It is to be noted that all the above effects belong to the *maximum* kinds and, of course, reach their development only under the most favorable conditions in each case respectively.

† Preliminary Report on the Geology of New Brunswick: Fredericton, 1865.

‡ In southern New Brunswick Prof. Bailey and Mr. Mathew have discovered and described rocks of Laurentian and Huronian age. "Observations on the Geology of Southern New Brunswick:" Fredericton, 1865. Also see an able paper by Mr. Mathew in the Journal of the Geological Society of London for 1865.

bay of Chaleurs to the boundary line between New Brunswick and Maine are supposed to represent the Laurentian and are described in my Report on New Brunswick, published in 1865 (pp. 42–52).

Geological maps of Nova Scotia were published by Dr. Abraham Gesner in 1836,* by Dr. Dawson in 1865,† and in 1868,‡ and by Sir William E. Logan in 1865§ and in 1869.‖

Sir William Logan states, in the introduction to his Atlas of Maps and Sections, that for the geology of Nova Scotia "a manuscript map by Dr. J. W. Dawson, compiled from his own resources, and those of Messrs. B. Brown and H. Poole, has been the source of information." Hence, in making the necessary comparisons between the subject of this paper and the published descriptions and maps of Nova Scotia, I shall have to refer almost exclusively to Dr. Dawson's map of 1868, accompanying the 2d edition of his beautiful work on Acadian Geology.

In a Preliminary Report¶ on the supposed Laurentian of Nova Scotia, I have quoted some passages from Dr. Dawson's work, especially the explanation to the geological map, in which the uncertainty of the boundaries of formations, and the doubtful age of some strata, is adverted to. The recognition of a very large gneissoid area in Nova Scotia, supposed to represent two series not hitherto described as occurring in the Province, will enable some of the changes in part anticipated by Dr. Dawson to be foreshadowed with some degree of accuracy; and it is proper to repeat here Dr. Dawson's first paragraph of the "Explanations to the Geological Map":— "The map in this edition, though greatly improved, is still to be regarded as merely a rude approximation to the truth, and the coloring in many places, more especially in the interior, remote from the coast lines, is little more than conjectural."

In various parts of "Acadian Geology" reference is made to rocks which were suspected by Dr. Dawson to be older than the Lower Silurian slates and quartzites. (See particularly page 620, Acadian Geology, 2d edition). These will probably now be classed with the Huronian series; and the massive porphyroid granitoid gneiss on which they rest, with the Laurentian.

Dr. Sterry Hunt visited Nova Scotia in November, 1867 "for the purpose of making some observations on the gold-bearing

* Remarks on the Geology and Mineralogy of Nova Scotia: by Abraham Gesner; Halifax, 1836.

† Acadian Geology, 1st edition.

‡ Acadian Geology, 2d edition; Macmillan & Co., London, 1868.

§ Atlas of Maps and Sections; Montreal, Dawson Brothers, 1865.

‖ Geological Maps of Canada and the adjacent regions, 1869: London, Edward Standford.

¶ Preliminary Report on a Gneissoid Series underlying the Gold-bearing Rocks of Nova Scotia, and supposed to be the equivalent of the Laurentian System; Halifax, N. S., January 5, 1870.

rocks of that Province, with the view of comparing them with those of other parts of the dominion, and also of obtaining such information as might be useful in the event of a geological survey of Nova Scotia itself."

Dr. Hunt's stay in the Province was limited to four weeks in the months of November and December, and in the descriptions which he has given in his official report to Sir W. E. Logan* he quotes the following as the principal sources of information about the geology and mineralogy of Nova Scotia: Dr. Dawson's Acadian Geology, 1st ed.; Mr. Poole's Report, 1862; Mr. J. Campbell's Reports, 1862 and 1863; Professor B. Sillman's Reports on Tangier, Waverley and Montague Gold Fields, 1864.

Allusion is made in the Atlas of Maps and Sections of the Geological Survey of Canada to the opinions expressed in my Report on New Brunswick that much of the granites of that Province consist of altered sedimentary strata. "Much of what in Nova Scotia, New Brunswick and Maine, is represented on the map as intrusive rock (chiefly granite) probably consists of paleozoic strata altered *in situ* as already suggested by Dawson and Hind. See the latter's Report on New Brunswick, 1865, page 50." (Atlas of Maps and Sections, Geological Survey of Canada, 1865, page 20).

The remarkable similarity which exists between the rocks constituting part of the great gneissoid axis of New Brunswick and the gneissoid series now described of Nova Scotia, coupled with the equally marked similarity which obtains between the paleozoic strata resting on these gneisses in both Provinces (on the Nipisiquit in N. B.), satisfies me that they are of the same age.

2. *General Sketch of the Distribution of the Huronian and Laurentian Series in Nova Scotia.*

In this general sketch of the old gneissic rocks of Nova Scotia, they are grouped together. In succeeding paragraphs it is stated where the Huronian or Cambrian gneiss and schist rest on the old Laurentian gneiss as far as known.

The outcrop of the Laurentian and Huronian rocks in Halifax and Hauts counties, N. S., has been traced from a point seven miles west of Windsor on the Basin of Mines (Bay of Fundy) to the Atlantic coast at Cape Sambro, a distance of forty-eight miles in an air line, and sixty-four miles on the margin of the outcrop. This is the northeasterly boundary of an immense area of the same rock series which from information hereafter noticed I believe continues with variable breadth

* Report of Dr. T. Sterry Hunt, F.R.S., on the Gold Region of Nova Scotia; Ottawa, 1868.

to the Tusket Islands, near Yarmouth, a distance of about one hundred and thirty-five miles in an air line.

The area above described forms the western development of the Laurentian and Huronian gneisses and schists in Nova Scotia. It is separated from the eastern development by a narrow but profound valley occupied by Silurian strata, whose least breadth is eight miles. The outcrop of the southwestern boundary of the eastern development is not continuous, but embraces two areas near Grand and Fletcher's Lakes, and an area of unknown but very considerable and of variable width, stretching from Parker's Lake, with some narrow interruption of Silurian strata which have escaped denudation, probably all the way to the Strait of Canso and Chedabucto Bay, a distance of one hundred and twenty miles in an air line: so that, generally speaking, a Laurentian axis, capped here and there by strata of Huronian age, occupies Nova Scotia, certainly in one place at least forty-eight miles in breadth.

The existence in Nova Scotia of all formations from the Trias to the Laurentian, with the exception of the Permian,* may now be considered as established. Whether the rocks noticed in the foot-note are of Permian or Triassic age I am not able to say, but judging from the descriptions given of the relations of the Triassic to the Carboniferous by Dr. Dawson, I have hitherto considered small unconformable patches in Cape Breton as of Triassic age, and regarded them as the continuation of the Prince Edward Island series, resting on Lower Carboniferous rocks.

The entire series from the Lower Carboniferous downward, with the exception of the Devonian, is passed over in a journey by rail from Windsor to Halifax, in a distance of fourteen miles. The Devonian occurs at Nictau, and rest there on Upper Silurian slates† which probably sweep round the Falmouth mountains and connect with the Upper Silurian near Windsor.

3. *Sequence of Formations—The Upper Silurian.*

On the St. Croix river, eight miles from Windsor, the Lower Carboniferous grits are seen to rest on Upper Silurian argillites.

* In Cape Breton, at Jumping Brook, seven miles northeast of Chetican Island on the Gulf coast, and at Trout Brook, five miles northeast above Chetican, mottled sandstones and conglomerates rest unconformably on white and mottled sandstones and bituminous shales, supposed to be of Lower Carboniferous age. These latter rest unconformably, the first on red metamorphic rocks, the second are seen in close proximity to red, green, and black corrugated schists, supposed to be of Lower Silurian age. In Dr. Dawson's tabular view of the geological formations of the Acadian Provinces (page 19, Acad. Geology) the Permian is stated to be "not represented unless by the lower part of the sandstones of Prince Edward Island." May not the unconformable patches in Cape Breton be a continuation of these Prince Edward Island deposits?

† Page 498 Dawson's Acadian Geology, 2d edition.

The grits dip N. 60° W. ∠5°; the argillites S. 70° E. ∠50°. The argillites are generally very fine grained, green internally, but red on weathering; they are interstratified with thin beds of quartzites, and have a breadth near the railway of 170 chains; their dip being tolerably uniform, and no repetitions visible; their thickness may approach 9,000 feet.

The argillites resemble in every particular argillites seen on the Tobique in New Brunswick, and there associated with their calcareous beds, holding *Favosites Gothlandica.* These are described in my report on New Brunswick.*

Toward the upper portion of the series the argillites are conformably succeeded by bluish-black slates, holding cubical crystals of iron pyrites, and resembling roofing slates. A similar change occurs on the Tobique in New Brunswick. These bluish-black slates are exposed to a great extent on the Ardoise hill range, N. S.

4. *The Lower Silurian.*

A good exposure of the blue-black Upper Silurian slates is visible at the 13th telegraph post south of Ellerhouse station on the Halifax and Windsor Railway, dipping S. 20° E.; and at the 38th telegraph post brilliant micaceous schists, interstratified with black corrugated slates, dip N. 40° E., the intermediate space being covered with boulder drift. The brilliant micaceous schists, as well as the corrugated slates, are much contorted, and overlie conformably the gold-bearing quartzite series.

The micaceous schists and the corrugated black slates cannot be distinguished from similar schists and slates described in my New Brunswick Report as occurring on the Nipisiquit, and near Dumbarton station on the New Brunswick and Canada Railroad (pp. 147 and 154) where they are associated with the red slates supposed to be the uppermost member of the Quebec group of Sir W. E. Logan. The black corrugated slates contain conformable auriferous beds of quartz, but no mining is at present carried on in these deposits. They are about 3,000 feet in thickness.

5. *The Gold-bearing Rocks.*

The known gold-bearing rocks of Nova Scotia consist of quartzites, sandstones and grits, interstratified with argillaceous slates, and thin conformable and intercalated beds of auriferous quartz. The portion has an ascertained thickness of 9,000 feet, and, between the base and a vertical thickness of about 3,000 feet from the summit, the thin beds of quartz are found yielding gold, and are worked in different districts in the Province, so that a mass of strata having a thickness of six thousand

* Page 131.

feet, or more than a mile, yields gold from quartz beds of contemporaneous age with the quartzites and slates with which they are interstratified; and it is from these quartz beds that the greater part of the gold of Nova Scotia is obtained.* The total thickness of the gold-bearing series, including the corrugated black slates and the brilliant micaceous schists, is about 12,000 feet.

6. *The Cambrian or Huronian Series.*

In some parts of Nova Scotia the known gold-bearing rocks rest unconformably on a gneissoid series, which are well exposed to view on the Halifax and Windsor Railway, between Stillwater and Mount Uniacke Station, near the village of Sherbrooke, in Guysborough county. This series is composed of beds of gneiss, interstratified with micaceous schists, schist conglomerate, beds of true quartzite, and grits. The gneiss is sometimes porphyritic, and the upper beds are almost always conglomerate, holding pebbles and masses of schist, grits, and conglomerates, which are found in this series. Some of the gneissic strata are garnetiferous, as are also the micaceous strata. Between Stillwater and Mount Uniacke stations, the general strike of the Lower Silurian is N. 80° E., dip N. ∠80°; the prevailing strike of the Huronian is S. 50° E., the railroad track running for two or three miles on the strike of these rocks. Near to their junction with the Huronian, the Silurian schists are more altered than when remote, and hold numerous crystals of andalusite. This series has been very extensively denuded; and in some places Silurian, Huronian and Laurentian are seen in close juxtaposition. The thickness at Sherbrooke is about 1,300 feet.

When the preliminary report already referred to was in the hands of the printer, I satisfied myself by repeated observations, that a very decided unconformability existed between these supposed older strata and the gold-bearing series; also between the older strata and the Laurentian; and I have succeeded in discovering in various places:

1st. The unconformable contact of the Lower Silurian gold-bearing strata with the underlying gneissoid and schistose series;

2d. The unconformable contact of this gneissoid and schistose series with the old porphyritic gneiss which I had before described as Laurentian;

3d. The unconformable contact of the gold-bearing series with the old Laurentian gneiss, showing the absence of the intermediate gneissoid series, or the Huronian.

These several points of contact are visible at both extremities of a patch of Huronian strata about four miles broad, overlying

* See my report on the Sherbrooke District for a description of the auriferous lodes, distinguishing between contemporaneous and intercalated lodes.

the Laurentian on the Windsor and Halifax railway, commencing one mile or thereabouts southeast of New Stillwater station, and terminating at Uniacke's second lake, and more than half a mile west of Mount Uniacke station.

7. *The Laurentian Series.*

The rocks last described are visible, as already stated, in unconformable contact with a coarse porphyroid, granitoid gneiss near Stillwater station. The strike of the granitoid gneiss is N. 10° W.; dip W., at an angle of about 48 degrees. Five miles farther south, and within a third of a mile of Mount Uniacke station, the Silurian quartzites rest on the Laurentian gneiss—the quartzites having a strike N. 75° W., and the old gneiss N. 20° W. Between Stillwater and Mount Uniacke, the Huronian series rests on the old gneiss, and the Silurian on the Huronian; but north of Stillwater and south of Mount Uniacke the Silurian strata are in contact with Laurentian gneiss, and so continue until another patch of Huronian is reached,—this last named series appearing to cover comparatively small areas in the great Laurentian valley between Halifax and Windsor; but in the more western counties it is exposed, I have reason to believe, to a very considerable extent.

In the county of Guysborough the gold-bearing rocks at Sherbrooke rest on the Huronian, which again is seen close at hand in contact with the old Laurentian gneiss. In the middle and eastern part of Nova Scotia the thickness of the Huronian does not appear to be very considerable, but no complete section has yet been crossed except at Sherbrooke. Between Halifax and Windsor the Lower Silurian series occupies a great valley or synclinal fold in the old Laurentian gneiss. The average breadth of the valley is nine miles, and its depth must exceed two miles. Its general course is northwest (true); and the gold districts of Mount Uniacke and Hammond's Plains are arranged on its western boundary; and those of Lawrencetown, Montague, Waverley and Renfrew on the eastern boundary of the valley, occupying crowns of anticlinals, which have a general northeast-by-east direction.

In one part of the county of Guysborough, the Laurentian, with a narrow band (as far as known) of Huronian, forms a nucleus, having an area of about 120 square miles. Around this nucleus the gold districts of Cochrane's Hill, Sherbrooke, Wine Harbor, Isaac's Harbor and County Harbor, are arranged, also on the crowns of anticlinals, which have a general easterly and westerly direction.

The profound Silurian valley between Halifax and Windsor, divides the Atlantic portion of Nova Scotia proper into two distinct geographical areas, in both of which the old porphyroid

Laurentian gneiss forms the axis around which the Huronian and Silurian series are arranged; but with respect to the precise limits of their formations little is known to the west or to the east.

From Dr. Dawson's published maps and descriptions, Mr. Poole's manuscript maps of the western part of the peninsula, and the numerous rock specimens collected by that gentleman, and placed at my disposal by the Commissioner of Mines, coupled with valuable information derived from other sources, I infer that this coarse Laurentian gneiss extends in one unbroken sheet of strata, but of variable width, a distance of ninety miles west of Windsor, and occupies a large portion of the uninhabited wilderness in that part of the Province. Much of the gneiss, schist and mica slate, seen by Mr. Poole, and described in his Report, and illustrated by his specimens, together with the gneiss, mica schist, and chloritic beds alluded to by Dr. Dawson, and by that geologist long spoken of as probably older than the Lower Silurian, are probably representations in many instances of the Huronian in the district where they occur.

8. *The Eozoön Canadense.*

In the autumn of 1868, Dr. Honeyman, then engaged on the geological survey of Canada, discovered on the Gulf coast of Nova Scotia, in the Arisaig district, and near the base of the Antigonish mountains, syenites, diorites, and crystalline limestone, with serpentine, which he then supposed were of Laurentian age, as he informed me subsequently to the publication of my Preliminary Report on the Nova Scotia Laurentian. Specimens were sent to Montreal for examination, and instructions were given by Dr. Hunt, who also shared Dr. Honeyman's opinion, to the lapidary, to prepare sections of the serpentinous rock, for microscopic examination. By some mischance this was neglected, and the specimens remained unexamined and indeed forgotten, until quite recently, as Dr. Hunt informs me, under date Feb. 3d, 1870. When submitted to the microscopic test, the *Eozoön Canadense* was distinctly seen, and Dr. Dawson has confirmed the observations.

This fortunate occurrence has a two-fold bearing. It not only affords most satisfactory testimony to the existence in Nova Scotia of the Laurentian limestones, but it enables geologists to recognize the truth of Dr. Honeyman's opinions, although by an accident these opinions were not made known or confirmed until after the publication of my Report. It is with pleasure I take advantage of the permission Dr. Hunt has given me in the letter above referred to, to use the information respecting the recent discovery of the *Eozoön* in the Antigonish limestones as I may think fit; and I am rejoiced that the publication of my official

Report announcing the series over a wide extent of country has resulted in the just though tardy recognition of the correctness of Dr. Honeyman's views with reference to the age of the limestones and diorites of Arisaig.

In other parts of Nova Scotia the Laurentian is yet known only in the form of coarse porphyroid gneiss; but the area it occupies is a lake and forest wilderness frequented only by the lumberman and the hunter.

The descriptions given by Sir W. E. Logan of a similar rock in the Laurentian of Canada apply exactly to the characteristic strata in Nova Scotia. "The coarse-grained granitoid and porphyritic varieties, which often form mountain masses, sometimes have, at first sight, but little the aspect of stratified rocks, and might be mistaken for intrusive granites." *

9. *Cape Breton Island.*

The undoubted recognition of the Laurentian limestones and serpentines in the Arisaig district of Nova Scotia is of great significance, and an important link in the chain of evidence which will ultimately establish the correctness of my supposition that a great belt of rocks, of the age of the Laurentian series, is exposed at short intervals apart from Newfoundland in latitude 51° to Shelbourne in Nova Scotia, latitude 44°.†

In Cape Breton Island I saw in 1866 the black corrugated slates forming the summit of the gold-bearing series in Nova Scotia, about five miles north of Chetican Island on the Gulf coast; and on the Mackenzie river, near Red Cape, I crossed part of a great gneissoid series.

In other parts of Cape Breton I have seen similar gneisses as, for instance, near the mouth of North river, St. Ann's Bay, and on the peninsula opposite Baddeck.

Dr. Honeyman informs me that he considers the gold-bearing rocks of Middle River in Cape Breton to be of the same age as those of Nova Scotia. Hence it becomes more than probable that a large portion of the area colored by Dr. Dawson to represent Upper Silurian in the northern part of the Island is occupied by rocks of Huronian and Laurentian age.

Around the outcrops of these rocks, wherever the Lower Silurian reposes on either one or the other, we may expect to find new workable gold deposits occupying the crowns of anticlinals which intersect the country with remarkable uniformity.

Hence we may legitimately anticipate that the correct mapping of these ancient rock series may be attended with considerable economic advantage to the Province.

* Page 587, Geology of Canada, 1863.

† Page 11, Preliminary Report on a Gneissoid Series in Nova Scotia, by the author.

ART. XXXVIII.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. 10.—*On certain Double Sulphates of the Cerium Group;* by CHARLES H. WING.

SOME years since Dr. Wolcott Gibbs found that, if to a solution of crude ceroso-ceric sulphate, containing also lanthanum and didymium, solutions of luteocobaltic or roseocobaltic sulphate be added, crystalline precipitates are formed, even from quite dilute solutions, insoluble in an excess of sulphuric acid. Different preparations of these have since been analyzed by different persons in this laboratory without obtaining rational formulas or accordant results. I therefore, at the suggestion of Dr. Gibbs, undertook the investigation of these compounds.

Swedish cerite was first heated to redness then quenched in water, after which, it was readily pulverized. The powdered mineral was heated with sulphuric acid, with tumefaction and solidification of the mass; this was pulverized, more sulphuric acid added, and the mixture placed in a crucible, which was then set in a deep furnace and supported by a fire-brick in such a manner as to be raised above the fire; it was thus heated by reverberation, to low redness, for four or five hours.

The resulting mass was of a reddish tint and crumbled readily to powder; this was diffused gradually in cold water and the solution filtered. The filtrate was precipitated by sulphydric acid,* filtered, oxydized by chlorine and precipitated by oxalic acid. The resulting oxalates, well washed and dried, served as the material for the following work.

To prepare perfectly pure cerium from these oxalates I used the method employed by C. Wolf. [This Journal, vol. xlvi, May, 1868.] The oxalates were decomposed by heat with constant stirring to favor oxydation. The resulting brown powder was dissolved in nitric acid; the solution concentrated, and precipitated by pouring it into a large quantity of boiling water containing 2 c. c. of sulphuric acid to the liter. The supernatant liquid had no trace of yellow, but an amethystine tint, and was reserved for the preparation of lanthanum and didymium.

The basic sulphate thus precipitated was washed by decantation with hot water, until the amount of soluble substance that remained in the precipitate had been reduced, (after Bunsen) to $\frac{1}{10,000}$.

The precipitate was then dissolved in nitric acid, the solution concentrated and precipitated by pouring it into a large quantity of boiling water. This precipitate was washed as before, redis-

* This was the process of Marignac, modified by Bunsen and others.

solved, again precipitated, and this process repeated till six successive precipitations as a basic salt had been effected. The final precipitate was dissolved in sulphuric acid, reduced by sulphurous acid, the solution evaporated and the excess of acid expelled by heating in, what I shall, for brevity, term a "radiator." This is a crucible of sheet iron in form like the ordinary porcelain crucible, midway in which is fixed a triangle of platinum wire by which a smaller crucible may be supported so as to leave a space of about 2 c. m. intervening between the walls of the two crucibles. The substance being placed in the inner crucible and the heat of a Bunsen gas lamp applied to the outer one, a very uniform heat may be maintained, variable at will, to a temperature considerably above the boiling point of sulphuric acid.

The neutral cerous sulphate thus obtained was dissolved in cold water, filtered, and crystallized by slow evaporation on the water bath.

A saturated solution of this salt was placed in a 12-inch saccharometer tube before a powerful spectroscope, and light, condensed by a "bulls eye" lens and transmitted through this tube, showed no traces of didymium.

The cerium also from the mother liquor from the last precipitation as basic salt, subjected to the same rigid test proved free from didymium.

The first precipitation of basic sulphate was of a dirty buff, every succeeding one lighter in color, the last three being almost white.

The cerous oxalate from both precipitate and mother liquor of the last precipitation was of a snowy whiteness, with no trace of amethystine tint by reflected light, and gave on ignition a white ceroso-ceric oxyd.

The cerous sulphate, the preparation of which has just been described, was, after repeated crystallizations, subjected to analysis, as follows. Portions of the salt dried at 100° C. were heated in the "radiator" until a weight was obtained which remained constant at an increased temperature. The anhydrous salt dissolved in a considerable amount of water was precipitated, hot, by a strong boiling solution of oxalic acid, and allowed to stand for twenty-four hours.

For the reduction of the weight of the ceroso-ceric oxyd, obtained by ignition of the oxalate to the corresponding amount of cerous oxyd, the experiments of Jegel* and Wolf† made in Bunsen's laboratory, give the following factors.

Jegel,	·9504	·9507	----	----	----	mean	·95055
Wolf,	·9507	·9518	·9494	·9509	·9518	mean	·95089

* Annalen d. Chem. u. Pharm., cv, 1858. † This Journal, vol. xlvi, May, 1868.

As the mode of preparation was that employed by Wolf, I have used the factor deduced from the mean of his analyses.

I. 1·2885 grms of substance gave ·1707 H_2O and ·6732 Ce_3O_4= ·6400 CeO.

II. 1·4090 grms. " " " ·1857 H_2O and ·7372 Ce_3O_4= ·7009 CeO.

These results give the following percentages, to which I have, for the sake of comparison, appended those obtained by Wolf from his purest cerous sulphate.

	I.	II.	Wolf.	
CeO	57·28	57·31	57·294	57·310
SO_3	42·72	42·69	42·706	42·690
equivalent corresponding	45·64	45·69	45·66	45·69

Taking the mean of these 45·67 as the true equivalent of cerium or 91·34 as the atomic weight and the formula

$$3(Ce, SO_4)+5H_2O$$

we have

	I.	II.	Wolf.		Calculated.
Ce	42·26	42·35	-----	-----	42·03
SO_4	44·50	44·47	-----	-----	44·17
H_2O	13·24	13·18	13·318	12·803	13·80

From the results obtained we can assume the cerium used in this investigation to be as pure as any yet prepared.

The following method was employed in the analysis of these compounds. The substance dried at 105° C. was heated in the "radiator" to decompose the ammonio-cobalt base. The residue was dissolved in a considerable amount of boiling water, and precipitated by a hot solution of oxalate of ammonia containing free oxalic acid. Care must be taken to add so much oxalate as shall serve to keep the cobalt in solution as a double salt. After standing for twelve hours or more, the solution was filtered off, the precipitate ignited, and weighed as ceroso-ceric oxyd of a composition as before stated. The blowpipe failed to detect cobalt in the ignited precipitate. The filtrate containing the cobalt was supersaturated with ammonia and precipitated by sulphydric acid at a boiling heat. The precipitate dried, roasted in a porcelain crucible, converted into sulphate in the crucible by means of aqua-regia and a few drops of sulphuric acid, was heated in the "radiator" until sulphuric acid fumes ceased to be evolved, afterwards over the naked flame, for a few moments, to low redness. The crucible was then allowed to cool, a single drop of aqua-regia and one of sulphuric acid added, again heated as before and finally weighed; care was taken to guard against absorption of moisture, while weighing, which the anhydrous salt is very prone to, and in no case did the sulphate, on subsequent treatment with water leave an insoluble residue.

In order to test the accuracy of weighing cobalt as sulphate, a method of determination employed and recommended by Gibbs and Genth,* some analyses were made of purpureo-cobaltic chlorid, an anhydrous salt of perfectly definite composition and one easily obtained in a state of purity. This salt, dried over sulphuric acid, was weighed in a porcelain crucible, sulphuric acid added and the cobalt converted into anhydrous sulphate by heating as above.

	I.	II.	III.	IV.	V.
Substance taken	·9005	·4041	1·2340	1·0478	1·0413
$CoSO_4$ obtained	·5573	·2498	·7625	·6497	·6443
Percentage $CoSO_4$	61·90	61·81	61·80	62·01	61·89
			Mean		61·88

Gibbs and Genth obtained as a mean of four analyses of this salt 61·90 per cent of $CoSO_4$.

Taking the atomic weight of cobalt as 59· which number is indicated by these analyses, we have as the percentage of cobalt found—

I.	II.	III.	VI.	V.	Mean	Calculated.
23·56	23·53	23·53	23·60	23·56	23·556	23·56

From the above it appears that this method for determination of cobalt is all that could be desired.

In determining the sulphuric acid in the substance a portion was digested, on the water bath, with a little strong hydrochloric acid for a short time, then dissolved in water and precipitated by acetate of baryta, with addition of chlorid of ammonium, at a boiling heat, and allowed to stand for twelve hours or more before filtering.

The total amount of hydrogen was determined by combustion of the substance mixed with chromate of lead, placing in the anterior portion of the tube, first oxyd of copper, then metallic copper freed from hydrogen.

The following preliminary experiments were made. To an acid solution of crude ceroso-ceric sulphate was added a solution of luteo-cobaltic sulphate in excess. To the solution filtered from the resulting precipitate, permanganate solution was added when a further precipitation of cerium ensued. This seemed to indicate the compound formed to be a ceric salt.

The filtrate from this last precipitate showed powerful didymium bands. (I think as many as thirteen bands were made out, certainly eleven) and was proved free from cerium by Gibbs' test,† with peroxyd of lead.

* "Researches on the ammonia-cobalt bases." Smithsonian Contributions to Knowledge, 1856.

† This Journal, vol. xxxvi.

The precipitates, being found to contain didymium, were converted into sulphate, oxydized by boiling with peroxyd of lead and again precipitated by luteo-cobaltic sulphate. This last precipitate was also found to contain traces of didymium.

Weighed quantities of crude ceroso-ceric oxyd were converted into sulphate, luteo-cobaltic sulphate and potassic permanganate added, and the yellow precipitates collected on weighed filters and, after weighing, converted into ceroso-ceric oxyd.

I. ·5638 grms. substance gave 2·0395 grms. of yellow salt, yielding ·4780 grms. ceroso-ceric oxyd.

II. ·6960 grms. substance gave 2·3670 grms. of yellow salt, yielding ·5940 grms. ceroso-ceric oxyd.

The filtrates were free from cerium.

	In original substance.		In yellow salt.	
	I.	II.	I.	II.
Per cent of Ce_3O_4	84·78	85·35	23·44	25·09

It appears from this, that the yellow salt, formed in this manner, cannot be relied upon, as possessing a uniform constitution.

A quantity of pure ceroso-ceric sulphate was precipitated by adding a slightly acid solution of luteo-cobaltic sulphate; the precipitate was washed with hot water. The washings were slightly colored to the end, indicating partial decomposition of of the salt. The precipitate on drying adhered to the filter and was of a rather pale yellow color.

III. 2·1175 grms substance gave ·5640 Ce_3O_4 and ·4405 $CoSO_4$
1·2725 " " " 1·4035 $BaSO_4$

		Ratio.
SO_4	45·43	9466
Ce	21 55	4717
Co	7·92	2685

This analysis leads to no rational formula.

A new preparation of this salt was made from a somewhat acid solution of pure ceroso-ceric sulphate and washed with hot water containing acetic acid. The precipitate was of a deeper color than the preceding and did not adhere so strongly to the filter.

IV. 1·8615 grms. substance gave ·4060 Ce_3O_4 and ·5050 $CoSO_4$

		Ratio.
Ce	17·65	3862
Co	10·33	3501

Another preparation made from nearly neutral ceroso-ceric sulphate was of much paler color, and adhered more strongly to the filter, than any previously made: this was not analyzed.

The above results led to the belief that the salt was contaminated with basic ceric sulphate.

A highly acid solution of pure ceroso-ceric sulphate was then heated and precipitated by a hot saturated acid solution of luteo-cobaltic sulphate. A bright yellow highly crystalline precipitate was formed, which was slightly washed with cold water, and which did not adhere to the filter on drying.

This precipitate when viewed under the microscope appeared as cleanly crystallized hexagonal prisms, of uniform size, and without admixture of other forms. Three preparations were, in this manner, made, which resembled one another in color and general character and which were separately analyzed.

V.	1·0345 grms. substance gave	·2160 Ce_3O_4	and	·2935 $CoSO_4$
	1·0240 " " "	1·2875 $BaSO_4$		
	1·7650 " " "	·5670 H_2O		
VI.	1·0075 " " "	·2150 Ce_3O_4	"	·2840 $CoSO_4$
	1·1665 " " "	1·4680 $BaSO_4$		
	1·1645 " " "	·3690 H_2O		
VII.	1·1330 " " "	·2455 Ce_3O_4	"	·3108 $CoSO_4$
	1·0017 " " "	1·2695 $BaSO_4$		
	1·3353 " " "	·4148 H_2O		

These results lead to the simple formula

$$12\,NH_3Co_2 3SO_4 + Ce_2\,3SO_4 + H_2O$$

This compound is of interest as being a purely ceric salt. It endures a temperature of 150° C. without decomposition.

	V.	VI.	VII.	Calculated.
SO_4	51·80	51·83	52·22	52·42
Ce	16·90	17·27	17·54	16·63
Co	10·80	10·74	10·44	10·74
NH_3	18·66	18·56	18·05	18·57
H_2O	2·47	2·21	2·39	1·64
	100·63	100·61	100·64	100·00

We now pass to the consideration of the corresponding cerous salt, which I found could be prepared by heating a nearly neutral solution of cerous sulphate and adding a hot concentrated solution of luteo-cobaltic sulphate so long as the supernatant liquid remained colorless. A yellow precipitate was formed, a little paler in color than the ceric salt, but showing to all appearances the same crystalline form. I regret much that I have, as yet, been unable to obtain crystals of such dimensions as would allow me to decide the question of isomorphism by actual measurement. I can at present only say, that the two substances cannot be distinguished from one another under the microscope.

VIII.	1·0240 grms. substance gave	·3050 Ce_3O_4	and	·2505 $CoSO_4$
	·8500 " " "	·9858 $BaSO_4$		
	·9588 " " "	·2650 H_2O		

The formula indicated is $12NH_3Co_23S\Theta_4+3(CeS\Theta_4)+H_2\Theta$.

	VIII.	Calculated.
$S\Theta_4$	47·77	48·40
Ce	24·10	23·04
Co	9·31	9·91
NH_3	16·10	17·14
$H_2\Theta$	2·07	1·51
	99·35	100·00

I succeeded also in forming the analogous salt of lanthanum. To a concentrated solution* of the sulphate, luteo-cobaltic sulphate was added, and the solution heated. The precipitate of a buff yellow color showed under the microscope crystals apparently of the hexagonal system with the edges so rounded as almost to conceal the hexagonal form.

IX.	1·0648 grms. substance gave	·3085 $La\Theta$	and ·2495 $CoS\Theta_4$
	·7852 " " "	·9072 $BaS\Theta_4$	
	·8918 " " "	·2452 $H_2\Theta$	

Assuming the atomic weight of this lanthanum to be 94, the probable formula is $12NH_3Co_23S\Theta_4+3(LaS\Theta_4)+H_2\Theta$.

	IX.	Calculated.
$S\Theta_4$	47·58	48·08
La	24·76	23·54
Co	8·92	9·85
NH_3	15·42	17·03
$H_2\Theta$	3·01	1·50
	99·69	100·00

Unsuccessful attempts were made to form double phosphates and chromates of cerium and luteo-cobalt.

Cerium was found to form with roseo-cobaltic sulphate compounds analogous to those formed with luteo-cobaltic sulphate. They are, however, easily decomposed by water, so much so, that an attempt was made to convert the ceric salt into basic ceric sulphate, by prolonged washing with hot water, with partial success.

X was formed by adding, to an excess of hot strongly acid solution of roseo-cobaltic sulphate, a solution of ceroso-ceric sulphate; this yielded a crystalline orange-brown precipitate which

* This solution contained also didymium and was obtained from the mother water of the first precipitation of basic sulphate before described, by "Watt's" process of boiling the ignited oxyd with chlorid of ammonium. This process affords a ready and satisfactory means of preparing a solution of lanthanum and didymium free from cerium, but has failed in my hands to remove all didymium from the cerium, even after the oxyds, prepared in various ways and ignited at different temperatures, had been boiled for hours, the solution of chlorid of ammonium being from time to time renewed, the residual oxyd converted into oxalate, ignited and again treated as before.

was slightly washed with cold water. The configuration of the crystals could not be well made out, but was apparently one of the complex forms of the regular system.

XI was formed by adding the roseo-cobalt solution to an excess of the cerium solution. The crystals formed were similar to X but larger.

X.	1·0661 grms. substance gave	·2395 gr. Ce_3O_4 and ·2908 $CoSO_4$
	1·3270 " "	" 1·6025 $BaSO_4$
	1·2715 " "	" ·3910 H_2O
XI.	1·9660 " "	" ·4702 Ce_3O_4 and ·4960 $CoSO_4$
	1·8938 " "	" 2·2970 $BaSO_4$
	2·0620 " "	" ·6037 H_2O

These results lead to the formula: $10\,NH_3\,Co_2\,3SO_4 + Ce_2\,3SO_4 + 5H_2O$.

	X.	XI.	Calculated.
SO_4	49·73	49·97	50·66
Ce	18·18	19·36	16·08
Co	10·39	9·60	10·39
NH_3	14·96	13·83	14·96
H_2O	7·00	7·31	7·91
	100·26	100·07	100·00

With cerous sulphate a homogeneous crystallization of the precipitate could be obtained only by adding the cerium solution to a large excess of roseo-cobaltic sulphate. The crystals under the microscope appeared in form like those of the ceric salt; and the remarks in regard to the isomorphism of the two luteo salts apply also to the roseo salt though with less force, insomuch as the appearance of the crystals is not so characteristic.

The analyses show the ceric and cerous salts to contain the same number of atoms of water which is in accordance with the supposition of isomorphism.

XII.	1·8118 grms. substance gave	·4700 Ce_3O_4 and ·4713 $CoSo_4$
	1·1235 " "	" 1·2877 $BaSO_4$
	1·6596 " "	" ·4880 H_2O

Which seems to indicate the formula: $10NH_3\,Co_2\,3SO_4 + 3(CeSO_4) + 5H_2O$.

	XI.	Calculated.
SO_4	47·23	46·90
Ce	20·99	22·31
Co	9·90	9·61
NH_3	14·27	13·85
H_2O	6·75	7·33
	99·14	100·00

I did not succeed in forming an analogous salt of lanthanum.

It appears that the proportional amount of cerium, in all the compounds discussed, varies, within certain limits according to the mode of preparation: which is well shown by a comparison of the results X, XI, XII. This is as we might expect in compounds, the nature of which precludes the possibility of purification, either by recrystallization or by thorough washing.

The roseo-ceric salt appears to contain some admixture of the cerous salt.

The sulphuric acid found is no doubt a little low, as the filtrate, after standing a week or more, deposited a slight additional precipitate of baric sulphate to the amount of ·05 per cent.*

The variations are, it seems to me, not so great as to cast doubt upon the correctness of the formulas deduced.

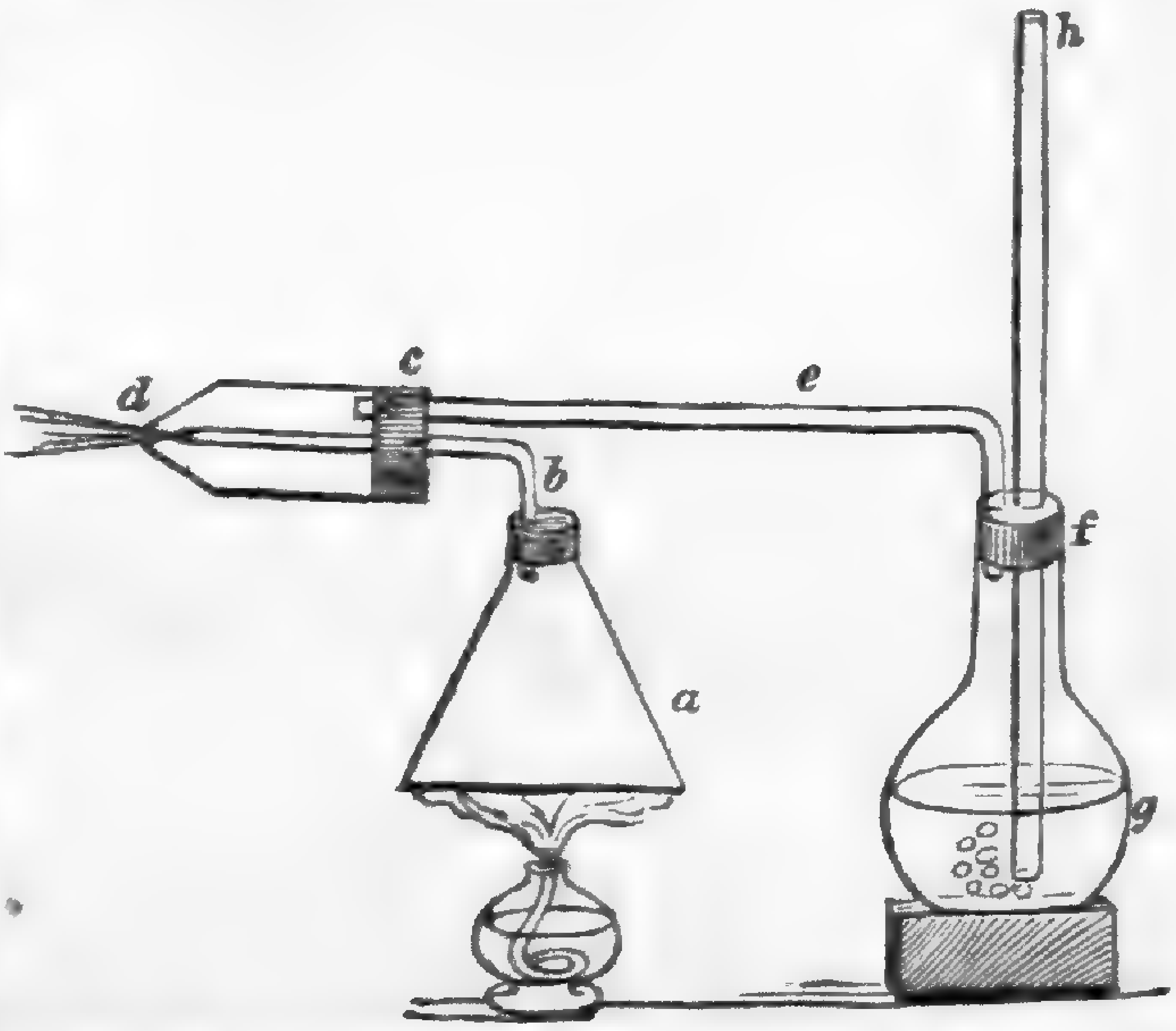
In conclusion, my best thanks are due to my kind teacher and friend, Dr. Wolcott Gibbs, to whom I am indebted for many and valuable suggestions, and also for the material used in this investigation.

Lawrence Scientific School, Cambridge, Jan. 15, 1870.

Art. XXXIX.—*On a new Aspirator;* by John C. Draper.

I send herewith a description of an apparatus that answers admirably as an aspirator when it is desired to submit a large amount of atmospheric air to examination.

It consists of a tin boiler (*a*) for the generation of steam; to this a bent tube, $\frac{1}{8}$ inch bore (*b*) terminating in a pointed extremity, or jet, is attached. The tube (*b*) passes air-tight through a cork (*c*) into a second tube (*d*), about one inch in diameter also drawn down to a jet as at (*d*) in the figure.



The two tubes form an arrangement somewhat like an ordinary oxy-hydrogen blow-pipe. Through the cork (*c*) a thin

* Compare Marignac, Ann. d. Chem. u. Pharm., lxviii, 212.

tube (*e*), $\frac{1}{4}$ inch bore, passes and terminates in the upper part of the flask (*g*) after perforating the cork (*f*). In the flask, any suitable test liquid, as lime-water, is placed. A tube (*h*) $\frac{1}{2}$ inch in diameter, freely opened at both ends, is then passed through the cork (*f*) to give the air access to the bottom of the flask when the apparatus is in operation.

The method of action is as follows: heat being applied to the boiler (*a*), a strong jet of steam issues through (*d*), when if the tubes (*b*) and (*d*) are properly adjusted, a powerful draught is established through (*e*), which draws air rapidly through (*h*). I have in this manner drawn air at the rate of a gallon a second through a column of lime-water eight inches in height.

By attaching an ordinary gas suction to this apparatus, the air could be measured and passed through an extensive system of flasks or tubes containing suitable re-agents for the determination of minute traces of various ingredients.

College of the City of New York, Jan. 14th, 1870.

Art. XL.—*On two peculiar products in the Nickel manufacture;* by Joseph Wharton.

I.

Seven years ago, when I was about to commence operations at Gap Nickel mine and furnace, I noticed among the fragments left by my predecessors a piece of nickel matte which contained occasional plates apparently of a metallic substance, tough, pliable, and elastic; these plates were about as thick as fine writing paper, from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. wide and about twice as long. No chemical examination of them was made except a slight qualitative examination showing the presence of nickel, iron, and copper.

Having on several occasions subsequently noticed some tendency to a similar appearance in the matte, I gave directions that, when it should next be observed, a close examination should be made, after the extinction of the furnace producing the peculiar matte, of the solid mass which always remains in the bottom of the furnace.*

This solid mass consists in part of lumps of ore, flux, and fuel of the first charge, which reached the hearth imperfectly melted or consumed and so remained, and in part of accretions from the thoroughly fused matte which, as the furnace worked, formed a pool over and enclosing those lumps.

* It should be explained that the furnaces in question are small upright blast furnaces, in which the ores of Gap Mine (Nicolliferous Pyrrhotite with 2 per cent Ni and Co), previously roasted, are smelted for the first time, the product being a matte containing about 12 per cent Ni and Co, with about 4 per cent Cu.

The cavities of such a mass seemed to me favorable for the production of crystals when a tendency to crystallize existed.

Last midsummer very interesting groups of crystals were in fact found upon breaking up one of these masses to fit it for remelting; they were so small, however, that, except for search being made in consequence of the matte of that furnace having exhibited the plates above named, the crystals would probably not have attracted attention.

Some of these crystals are cubical, with a bright metallic luster, the groups closely resembling miniature geodes of galena; others are minute octahedrons, arranged in spiculæ, and in dendritic or plumy forms, resembling the fern-like aggregations of zinc crystals which I sometimes found in the prolongs of my spelter furnaces at Bethlehem, Pa. Specimens of both cubes and octahedrons are forwarded with this paper.

These crystals are very tough, and are highly magnetic. A spicula of the octahedrons can be bent many times without breaking, and one which was floated upon water, after being lifted a few times by a magnet, pointed steadfastly to the north, and showed attraction and repulsion to the poles of a magnet just as a steel magnetic needle would under like circumstances.

A specimen of the octahedral crystals, and a specimen of the granular or almost crystalline solid matter to which they were attached, were submitted for analysis to the chemist of my establishment with the following results:—

	Crystals.		Granular.	
Cu	1·85	0·466	1·74	0·438
Ni and Co	25·22	6·837	28·20	7·640
Fe	64·10	36·622	62·50	35·861
S	8·90	43·925	7·60	43·939
	100·07	1 : 4·93	100·04	1 : 5·78

The subordinate column in each case shows the quantity of S which would be requisite to form, with the metals found, the compounds Cu_2S, Ni_2 and Co_2S, FeS; the ratio, below it, is that of the S found to that thus calculated.

If we conceive the copper to exist as Cu_2S, we then have 89·32 parts Fe, Ni, and Co in combination with 8·43 parts S: taking then the average atomic weight of the metals according to the proportions found, as 56·85, the atomic ratio of the metals to that of the sulphur is as 31·4 to 5·27, corresponding very closely to the formula R_6S.

Should the copper be included in the average, we get the figures R 32·00 S 5·56, indicating, though less accurately, the same formula.

II.

Desiring last year to make, in a granulated form, an alloy consisting of $\frac{3}{4}$ nickel, $\frac{1}{4}$ copper, I caused a mixture of the oxyds of those metals in the due proportions to be heated in closed crucibles with charcoal in a blast furnace; by this means reduction and fusion resulted, and the fused alloy was poured into water at a high white heat.

Among the granulated metal were found large numbers of hollow spheroids varying in size from peas to large chestnuts, many of them imperfect and torn, but many of them tolerably regular in shape, one side being usually bright and smooth, while the other was rough and pimpled.

As, upon crushing these with a hammer, the anvil was moistened, I examined a considerable number of them and found that they were nearly full of water, so that the water distinctly rattled within them when shaken, and showed itself in quantity when the larger spheroids were carefully broken. Fluid metal, poured white hot into water, had formed metallic bulbs filled with water.

For several days I carried some of these bulbs in my pocket, occasionally rattling the water in them, before the manner of their formation occurred to me. My first idea—that drops of metal falling upon the water were flattened by the blow, and that the edges then instantly clasped together and became welded, enclosing water within their grasp—was obviously untenable, for the eye could detect no seam or crevice, and besides, how could water exist as a liquid shut in by walls of this refractory alloy at a welding heat? Apple dumplings are formed in a manner somewhat similar to that, but these bulbs were not so formed.

The true solution is doubtless this: The metal when poured was in a state of ebullition, was giving off gas; not probably metallic vapor, but perhaps carbonic oxyd.

The separate globules into which the thin stream divided upon entering the water, were each emitting gas when contact with the water produced upon their surfaces an impervious film of solid or pasty metal. The continued evolution of gas in the fluid interior of such globules could have then no other effect than to distend the globule into a bulb, whose upper side might well be pimpled by the effort of tiny gas bubbles in the pasty shell to escape upward, while similar tiny bubbles working upward in the crust of the under side would reach the interior cavity, thus leaving the lower surface smooth and bright.

Multitudes of incipient globules were of course torn and distorted by reason of the internal gas finding a vent, and of course any which were rent must necessarily be filled by the water in which they were plunged. Those however in which the eye found no aperture were doubtless filled, after the coldness of the external water had so contracted the heat-rarified gas as to produce an approximate vacuum within the bulb, by the slow imbibing of water through minute pores to supply that vacuum. That such pores existed was shown by the fact of the bulbs all in time losing their water by exposure to a dessicating atmosphere.

Not all the pots of metal produced when poured, such globules, for not all were in the fit state of ebullition.

The nature of the disengaged gas might perhaps have been determined, if a sufficient quantity had been collected by breaking the globules under a receiver, but this was not done. I send specimens of the globules with this paper.

Philadelphia, March, 1870.

ART. XLI.—*On the action of sunlight on Sulphurous Acid;* by O. LOEW, Assistant in the College of the City of New York.

(Read before the "Lyceum of Natural Science," New York.)

WE know that plants under the influence of the sunlight reduce carbonic acid and water to organic compounds, and organized parts; we know further, that the albuminous principles, as well as some ethereal vegetable oils, contain sulphur which doubtless comes from the sulphates contained in the soil. As regards this reduction of sulphuric acid, it seemed to me of interest to ascertain whether sunlight possesses any reducing power upon the oxygen compounds of sulphur out of the tissues of the plant. For this purpose I exposed diluted sulphuric acid, solutions of sulphates and sulphites and aqueous sulphurous acid under various conditions, in sealed tubes to the sunlight during the last summer.

It was only with the sulphurous acid that any change was noticed. The tubes containing this substance *remained clear during two months*, but after that time a disturbance set in which slowly increased, and sulphur was deposited in a finely divided state.

The sulphurous acid was thus gradually reduced to sulphur, but the oxygen was not liberated, another part of the acid having been oxydized by it to sulphuric acid. It seems very singular that a space of two months elapsed before any change was observed; it appears that the absorption of a great amount of light was necessary for the separation of the first atom of sulphur, which was followed then by more atoms in much shorter intervals of time.

New York, December, 1869.

ART. XLII.—*On the formation of Ozone by rapid combustion;* by O. LOEW, Assistant in the Chemical Department of the College of the City of New York.

(Read before the "Lyceum of Natural Science," New York).

ACCORDING to the view of Schönbein, every slow oxydation is accompanied by formation of ozone, common oxygen not being able to combine directly with the elements. In 1858 Clausius advanced the hypothesis that ozone is oxygen in the state of *free atoms*, while common oxygen consists *of a molecule of two combined atoms.* But the later investigations of Andrews and Toit, Babo and Soret upon the volume of ozone have not supported this notion, and Clausius has modified his hypothesis accordingly, now believing that ozone is a combination between *an atom and a molecule of oxygen.* This combination is but a loose one, and the power of oxydation resides in the third atom of oxygen, which combines directly with other substances, leaving common oxygen behind. This constitution of ozone may be represented by the following formula:

$$3([OO])=2([OO]O)$$

The oxydation of a metal by ozone is shown by the equation $([OO]O)+M=M\Theta+([OO])$.

When we now take into consideration that ozone and antozone together give common oxygen, we must conclude that antozone is oxygen in the state of free atoms. Furthermore we see that common oxygen can be converted according to circumstances either into ozone or antozone. It seemed to me that in every combustion even the most rapid and energetic, an intermediate decomposition of the molecule of common oxygen must take place if the single atoms will enter into combination with the elements, and that ozone or antozone would be detected in a flame if the high temperature would not destroy it again as quickly as it is formed.

To prove this conclusion, I blew a strong current of air through a tube into the flame of a Bunsen's burner and collected the air in a beaker glass or balloon. I was thus able in a few seconds to collect enough ozone to readily identify it by its intense odor and by the common tests.

This observation shows that not only in slow oxydation but also in rapid combustion, an intermediate formation of ozone takes place,* and that it can be separated in the proper way.

New York, December, 1869.

* Compare the observation of Pincus in the article on Nitrification, this Journal, II, vol. ii, p. 238.—EDS.

ART. XLIII. — *Contributions to Zoölogy from the Museum of Yale College.* No. 7.—*Descriptions of New Corals;* by A. E. VERRILL.

MADREPORARIA.

Heteropsammia geminata, sp. nov. Figure 1.

1.

Corallum completely encrusting and enclosing a small, dead, univalve shell, which had been occupied by a worm (probably *Sipunculus*) by which a small circular opening was maintained. Base of various irregular forms, according to the form of the shell encrusted. Cup at first simple, slightly raised; it very early becomes elongated and finally divides by fissiparity, so as to form two equal and similar corallites, which are sometimes well separated and divergent, but more frequently closely contiguous. These corallites are but little elevated, becoming smaller toward the cup, which is circular, oval, or more or less irregular, and not very deep. Septa in five cycles, the last cycle more or less imperfect or wanting in some of the systems. The primary and secondary septa are narrow, much thickened and spongy outwardly, a little projecting; the septa of the fourth cycle are narrow and thin, outwardly joining those of the first and second, opposite the inner edges of the latter joined together in pairs, the inner and basal portion becoming broader before joining the columella, which is moderately developed and fine spongy. The coral has an open vermicular and quite porous texture, more compact beneath. In all the specimens there are several small holes, like pin-holes, near the base of the corallites, often forming a nearly complete circle around the base, which are, perhaps, made by parasites.

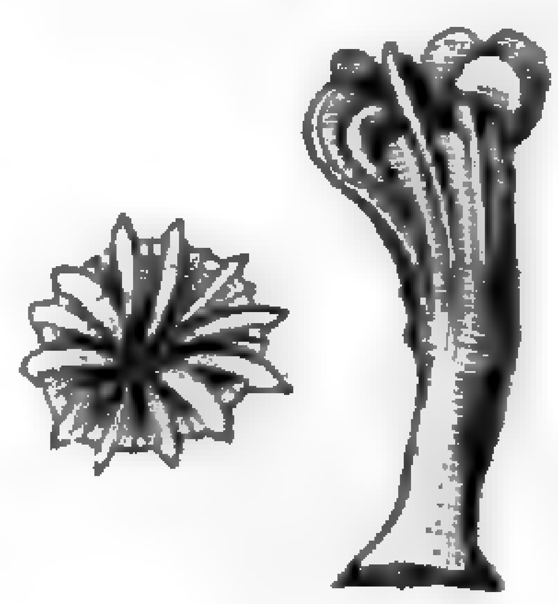
The base of the largest specimen is ·65 long; ·50 broad; ·45 high; corallites ·12 high; ·35 broad; depth of cell ·12 of an inch. Burmah,—W. H. Dall.

Of this species there are eighteen specimens of various sizes. It is remarkable as the second living species of this curious genus, and still more so as furnishing another instance of fissiparity in the family of *Eupsammidæ*,—a feature not hitherto recognized as normal in any genus except *Lobopsammia* of the Eocene. Doubtless the other species divide in the same way, for *H. Michelinii* E. and H. is described as having the cup shaped like the figure 8, which is the form in this species just before dividing. *H. Michelinii* appears to differ not only in dividing less freely, but in its smaller cup and a different arrangement of the septa, those of the three first cycles being described as about equal, while in *H. geminata* those of the third cycle are very small. The columella in the latter appears to be much less developed.*

Desmophyllum simplex, sp. nov. Figure 2.

Corallum elongated, slender, turbinate above, rapidly enlarging to the edge of the cup; lower half of column smooth and round, upper part, toward the cup, somewhat angular with twelve thin, sharp, crest-like costæ, which become much elevated near the summit; surface finely granulous. Cup distinctly angular, usually somewhat hexagonal, deep, very open, with a thin wall. Septa in three cycles; those of the third cycle very small, thin, very narrow, and but little elevated; those of the first and second broadly rounded at summit and a little excurved, perpendicular within, thin, the surfaces finely granulated, the primaries considerably the largest. Six corallites grow up together in an irregular cluster, several of these uniting together at base. The largest is ·80 of an inch high; ·12 in diameter at middle; the cup ·38; primary septa ·14 broad; height above edge of cup ·10 of an inch.

2.



St. Thomas, West Indies,—Mrs. E. H. Bishop.

HETEROZOANTHUS, gen. nov.

Polyps creeping on the surface of sponges, etc., by thin, basal, stolon-like expansions of the base, from which the polyps arise in linear series. The polyps are short, capable of contracting nearly to a level with the basal membrane. Tentacles few, 12 to 24. Integument stiffened by foreign bodies imbedded in the skin, such as sponge-spicula, etc.

Besides the following, this genus appears to include several other known species: *H. Swiftii* (*Gemmaria Swiftii* D. and M.) is parasitic upon a sponge in the West Indies; *H. Axinellæ* (Schmidt sp.) on two species of *Axinella*, Adriatic Sea.

Heterozoanthus scandens, sp. nov.

Polyps small and low, connected by a narrow basal membrane, which is a little wider than their bases and creeps over and is partially imbedded in the surface of a branching sponge, rising to the tips of all the branches, some of which are eight inches long, and forming irregular reticulations over the surface, though at times ascending for two inches or more with a linear series of polyps; rarely with double series. The polyps are near

* *H. eupsammides* (Gray sp.) from China, may be nearer this if distinct from the former, to which Edwards and Haime refer it.

together, seldom more than their own diameter apart, and often in contact; in contraction they rise but little above the basal membrane in the form of low, flattened warts, with a depression at summit from which radiate 12 to 15 sulcations. Internal lamellæ 12. Integument firm, filled throughout with small, glistening, white spicula, probably derived from the sponge. Diameter of contracted polyps ·08 to ·10; height ·02 or ·03; breadth of basal membrane about ·10 of an inch.

Sherbro Island, West Africa,—Prof. A. Hurd.

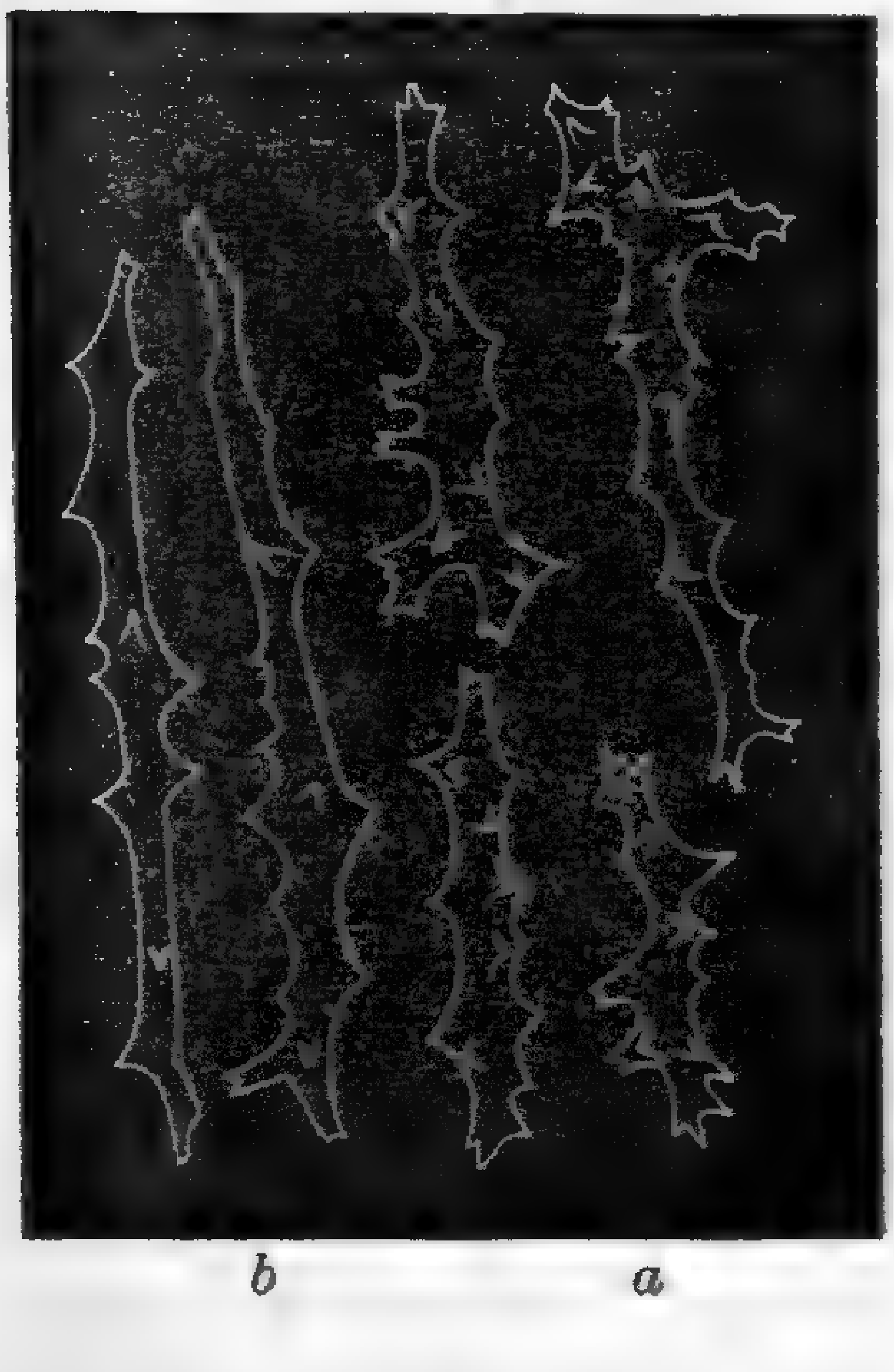
Alcyonaria.

Telesto Africana, sp. nov. Figure 3.

Corallum forming a cluster of long, rather slender, branched, tubular stalks connected by a creeping base. The stalks are 2 to 4 inches long, with eight longitudinal ridges or low costæ. The polyps are arranged irregularly along the sides of the branches and main stalks, mostly at distances of ·10 to ·25 of an inch apart, sometimes opposite, and in contraction are prominent, tubular, and placed obliquely, sulcated with eight grooves. Color when dried yellowish white. Diameter of stalks ·06 to ·08; of polyp-tubes ·05; length of polyp-tubes ·10 to ·12 of an inch when contracted.

The walls of the stalks and branches consist of rather slender rudely, irregularly, but sparingly branched and spinulose spicula of various forms (fig. 3, a), which are closely interlaced, as in the other species of the genus. Other forms of long, very slender, more distantly spinulose, often bent spicula are also abundant (fig. 3, b).

3. $\frac{100}{1}$



b *a*

The stouter spinulose spicula measure ·252mm by ·036mm, ·192 by ·060, ·192 by ·048; the long slender spicula ·528 by ·024, ·492 by ·036, ·456 by ·066, ·432 by ·036, ·420 by ·036, ·408 by ·048, ·366 by ·048.

Sherbro I., on the base of *Muricea granulosa*,—Prof. A. Hurd.

This species is closely allied to *T. fruticulosa* Dana, of the Carolina coasts, and, like that species, is encrusted by a parasitic sponge. But it is a more slender species and the spicula are longer and more attenuated.

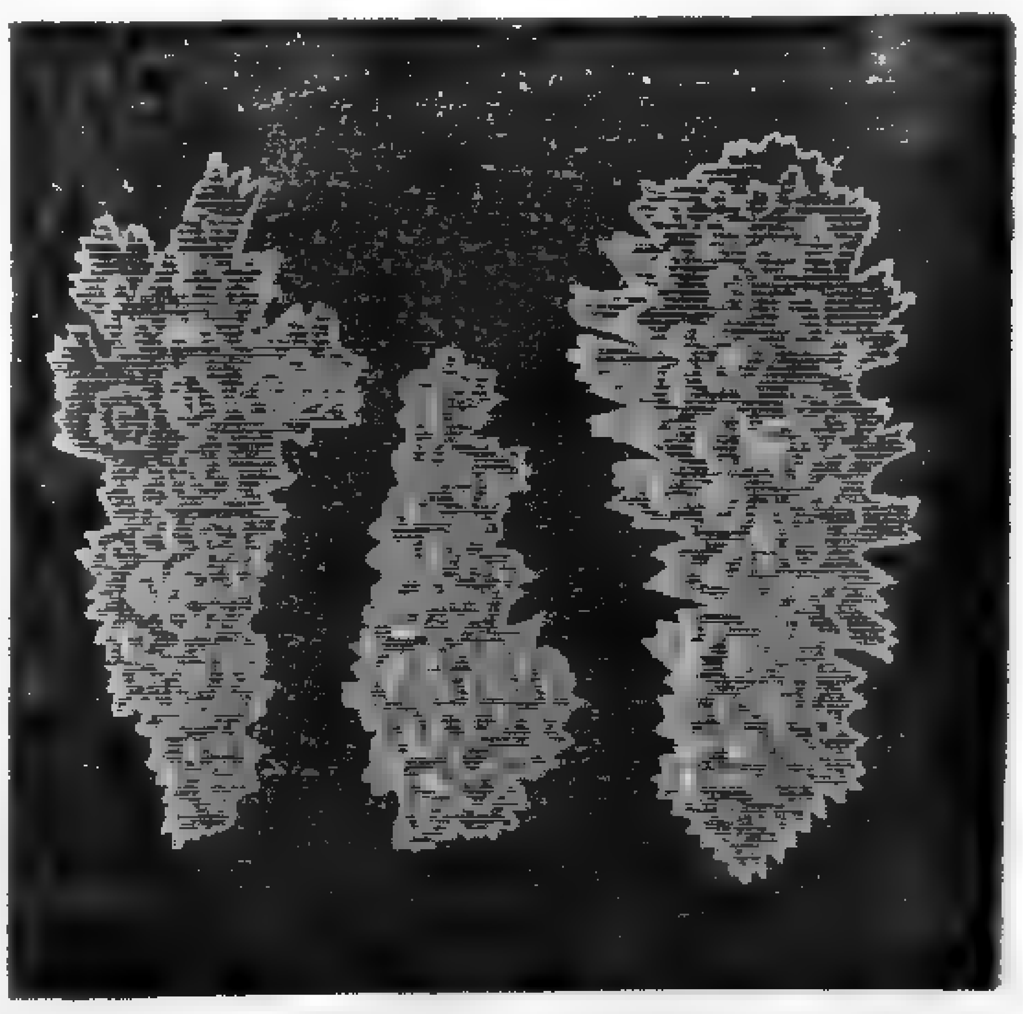
T. Riisei V., of St. Thomas (*Clavularia Riisei* D. and M.), is also nearly allied. *T. trichostemma* V. (Dana sp.) and *T. aurantiaca* Lamx. have stouter and more warty spicula.

Muricea granulosa, sp. nov. Figure 4.

Corallum rather slender, somewhat fan-shaped, branching in a plane; branches and branchlets irregularly sub-pinnate; branchlets slender, ·5 to 1·5 inches long. Verrucæ small, crowded, prominent, somewhat nariform, opening upward, the lower lip rounded, not prolonged. Cœnenchyma granulous with small, stout spicula. Color, when dried, dull yellowish or grayish brown. Height 6 inches; breadth 4; diameter of trunk ·15; of branchlets ·06 to ·08; of verrucæ ·03; height of verrucæ ·02 of an inch.

The spicula (fig. 4) are yellowish white and quite small for the genus; the larger ones are elongated, often curved, coarsely and roughly warted, stout spindles, tapering to acute ends; short, stout, roughly warted, irregularly oblong spicula with obtuse ends; and various short, stout, rough, club-shaped forms, which are often as broad as long, with large rough warts or spinules on the larger end. With these are various other forms of irregular spicula, with many smaller, rather slender, more regular, distantly and more evenly warted spindles.

4. $\frac{100}{1}$



The larger rough spindles measure ·648^{mm} by ·156^{mm}, ·504 by ·108; the oblong spicula ·408 by ·144, ·396 by ·168, ·312 by ·108, ·264 by ·108, ·264 by ·156, ·216 by ·096; the larger clubs ·396 by ·156, ·336 by ·144, ·288 by ·132, ·276 by ·120, ·264 by ·084, ·192 by ·108, ·180 by ·072; the largest of the slender spindles ·492 by ·096, ·444 by ·072, ·336 by ·072.

Sherbro Island,—Prof. A. Hurd.

This species is remarkable for the small size and roughness of the spicula and the form of the verrucæ. Its branches are also more slender than in most species.

Muricea vatricosa Kölliker (*Gorgonia vatricosa* Val.) from the Bizagos Archipelago is the only African species recorded previously. Of that we have received authentic spicula through Dr. Kölliker, from the original specimen. The spicula of *M. vatricosa* are much coarser and the corresponding forms are about twice as large; some of the larger spindles measure ·840^{mm} by ·180^{mm}, ·780 by ·240, ·744 by ·204; oblong spicula ·696 by ·240, ·456 by ·192; clubs ·660 by ·156, ·456 by ·180; the slender spindles ·720 by ·108. The lower lip is also said to be prolonged in the form of a small horn.

Leptogorgia robusta sp. nov.

Corallum consists of several stout principal branches arising from near the broadly expanded base; these main branches fork at irregular distances, and the secondary branches are irregularly pinnate, with branchlets mostly alternate on opposite sides, and ·5 to 1·5 inches apart. The branchlets are curved at base, then ascend at an angle of about 45°; they are rarely coalescent, stout, rigid, obtuse, 1 to 3 inches long, a little compressed, with a broad band of polyp-cells on each side, with narrow, depressed, sterile median bands, often with a distinct groove. The polyp-cells are numerous, close, rather large, oblong or oval, usually at the summit of large, low, rounded verrucæ, sometimes scarcely raised; they form about 4 to 6 irregular alternating vertical rows on each side of the branchlets, and 8 to 12 on the main branches, and are usually separated by distances about equal to their own diameter. Cœnenchyma moderately thick, finely granulous. Axis stout, round or a little compressed, nearly smooth and brownish black in the larger branches, the axils flattened; in the branchlets firm and rigid, tapering, dark reddish brown, slightly translucent; base thick, spreading, yellowish wood-brown.

Color of cœnenchyma dull dark yellow, tinged with purplish brown on the verrucæ. Height 12 inches; breadth 5; diameter of main branches ·22 to ·25; of axis ·12 to ·15; diameter of terminal branchlets ·13 to ·16; of their axis at base ·04 to ·05; diameter of verrucæ ·04 to ·05; height ·01 to ·03; diameter of cells ·02 to ·03 of an inch.

The spicula are small, bright yellow, intermingled with a few more slender ones that are bright purple; the latter mostly come from the verrucæ. Most of the yellow spicula are acute double-spindles, regularly tapering to each end, with three or four well separated whorls of warts on each half; some shorter and stouter forms occur, with more crowded warts and obtuse ends. The purple spicula are mostly slender, acute, sparingly warted spindles and double-spindles. Small, rounded, closely warted double-heads occur sparingly.

The larger yellow double-spindles measure ·216^{mm} by ·072^{mm}, ·204 by ·060, ·180 by ·072, ·168 by ·060, ·168 by ·066, ·156 by ·048; the purple spicula ·216 by ·036, ·204 by ·018, ·192 by ·030, ·180 by ·024, ·156 by ·030, ·144 by ·036.

Sherbro Island,—Prof. A. Hurd. Two specimens attached to the shell of an oyster, with *L. sanguinolenta* V.

This species somewhat resembles in mode of growth and general appearance *L. rigida* V. from the Gulf of California, etc., but has even stouter branches. The spicula and verrucæ are very different. The color of *L. rigida* is almost always uniform dark purple.

Leptogorgia dichotoma, sp. nov.

Corallum tall, slender, sparingly dichotomously branched. The trunk divides at about three inches from the base into two main branches; these fork at about 1 and at 2·5 inches, and part of the secondary branches divide again at about three inches from their origin, but others remain undivided for 6 or 8 inches. The branches and branchlets are long, rather slender, slightly tapering, obtuse, flexuous, spreading at base, compressed or somewhat quadrangular, with a narrow sterile band on each side, and broad lateral bands of crowded polyp-cells. The cells are rather large, oval, mostly raised on low, rounded, rather large, often crowded verrucæ, sometimes flat. Cœnenchyma moderately thick. Axis round, dark brown in the larger branches, light yellowish and setaceous in the terminal branchlets. Color bright lemon-yellow, the cells mostly surrounded by purplish.

Height 15 inches; breadth 4; diameter of main branches ·15; their axis ·09; diameter of branchlets ·11 to ·13; their axis at base ·05, in middle ·02 to ·03; diameter of verrucæ ·03 to ·04; height ·01 to ·02.

The spicula are yellow, with some more slender purple ones, as in the preceding species, but the average size is nearly twice as great. The most common forms are long, very acute, double-spindles, with four or five loose whorls of rough warts on each end; others are shorter and stouter, with more crowded whorls of warts. Some of the purple spicula are regular double-spindles, like those first described, but others, from the polyps, are slender spinulose spindles; some of the double-spindles are half purple and half yellow.

The larger double-spindles measure ·264^{mm} by ·060, ·252 by ·072, ·252 by ·060, ·240 by ·066, ·228 by ·084, ·228 by ·060, ·228 by ·054, ·216 by ·072, ·216 by ·060, ·204 by ·072, ·204 by ·060, ·192 by ·078; the purple polyp-spindles ·228 by ·024, ·186 by ·030, ·180 by ·018, ·168 by ·030, ·156 by ·030, ·144 by ·015.

Sherbro Island,—Prof. A. Hurd.

The new species herein described from the west coast of Africa are of peculiar interest, both as furnishing additional evidence of the richness of that little explored region in Gorgonacea, and as showing peculiar relations to the faunæ of the West Indies and Pacific coasts of America. They were collected by Mr. D. W. Burton, missionary, for the museum of Knox College, and sent to me for examination by Professor Hurd.

ART. XLIV.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. 11; by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

1. *On a simple method of avoiding observations of temperature and pressure in gas analyses.**

In absolute determinations of nitrogen and other gases, accurate observations of temperature and pressure are, in the ordinary methods of analysis, necessary, and when made require subsequent calculations which, when the analyses are numerous, become rather tedious. By the following simple method these observations may be altogether dispensed with, and the true weight or the reduced volume of the observed gas obtained at once by a single arithmetical operation. The volume of any gas at the temperature 0° C. and pressure 760 may be deduced from its volume at the temperature t and pressure p by the familiar expression:

$$V_0 = V_1 \frac{1}{1+0{\cdot}00367t} \cdot \frac{h-h'-h''}{760} \qquad (1)$$

in which h is the observed height of the barometer (reduced to 0° C.), h' the tension of the vapor of water at $t°$ when the gas is moist and h'' the height of the column of mercury in the collecting tube above the level of the mercury in the cistern. For any other gas under precisely the same circumstances of temperature and pressure we have the equation:

$$V'_0 = V'_1 \frac{1}{1+0{\cdot}00367t} \cdot \frac{h-h'-h''}{760} \qquad (2)$$

Whence dividing the first equation by the second we have:

$$\frac{V_0}{V'_0} = \frac{V_1}{V'_1} \qquad (3)$$

or as a proportion $\quad V_1 : V'_0 :: V_0 : V'_0 \qquad (4)$

from which it appears that the reduced volume (vol. at 0° and 760^{mm}) of the second gas may be found without observations of temperature and pressure, provided th t the unreduced volume be observed under the same circumstances of temperature and pressure as the volume of the first gas, the reduced volume of which has been previously determined. Let the first or standard gas be air; then if the weight of one cubic centimeter of dry air at 0° and 760^{mm} be w the whole weight will be wV_0. In like manner we shall have for the weight of the gas to be measured $w_1V'_0$, and since the weights do not change with the temperature and pressure, we have finally:

$$wV_1 : w_1V' :: wV_0 : w_1V'_0.$$

If now we suppose that the gas in the first tube, or standard

* Read before the National Academy of Sciences, Sept., 1869.

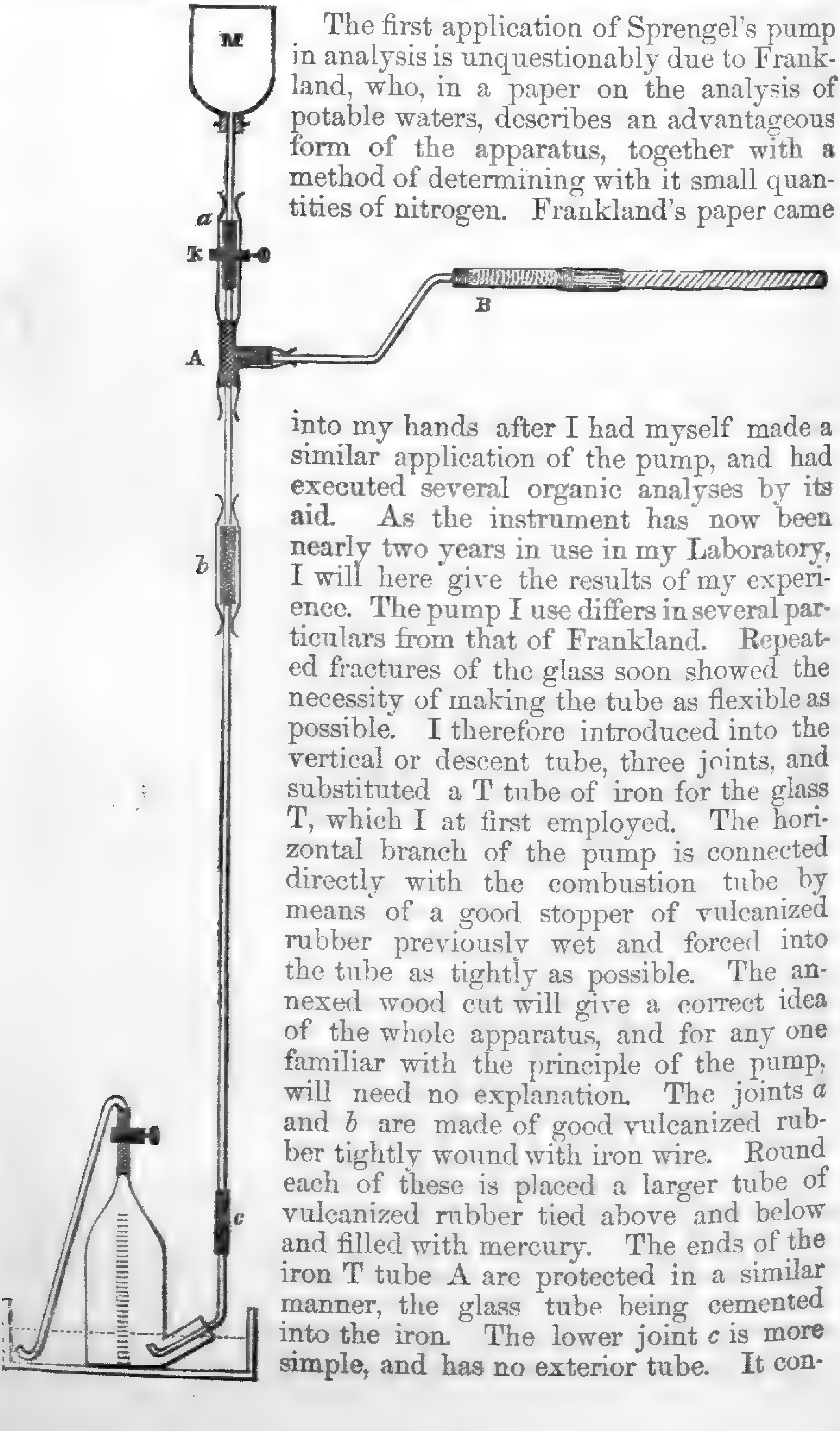
gas is, for example, nitrogen, the volume remaining the same, and that the gas to be measured is also nitrogen, we have

$$w_1\, V_1 : w_1\, V'_0 :: w_1\, V_0 : w_1\, V'_0$$

or simply $$V_1 : V' :: w_1 V_0 : w_1 V'_0. \qquad (5)$$

The application of this formula in practice is as follows: A graduated tube holding about 150 cubic centimeters is filled with mercury and inverted into a mercury trough. Two thirds or three fourths of the mercury are then displaced by air, care being taken to allow the walls of the tube to be slightly moist, so as to saturate the air. This tube may be called the companion tube; the volume of air which it contains must be carefully determined in the usual manner by five or six separate observations, taking into account, of course, all the circumstances of temperature and pressure. The mean of the reduced volumes is then to be found, and forms the constant quantity V_0. The gas to be measured is transferred from the receiver in which it is collected, into a (moist) eudiometer tube, which is then suspended by the side of the companion tube, and in the same trough or cistern. Both tubes being supported by cords passing over pullies, it is easy to bring the level of the mercury in the two tubes to an exact coincidence. The pressure on the gas is then the same in each tube. The temperature is also the same as the tubes hang side by side in the room set apart for gas analyses, and are equally affected by any thermometric change. It is then only necessary to read off the volumes of the gas in the two tubes to have all the data necessary for calculating the weight of the gas to be measured. This calculation may be effected in two ways, each of which will be found of use. Thus proportion (4) reads in words: as the observed volume of the air in the companion tube is to the observed volume of the gas in the measuring tube, so is the reduced volume of the air in the first—previously determined as above—to the reduced volume of the gas to be measured. This method of course applies to the reduction of any gaseous mixture whatever to the normal pressure and temperature. In absolute nitrogen determinations, however, proportion (5) gives the weight of the nitrogen measured at once, since the term w_1V_0 is found by multiplying the weight of 1 c.c of nitrogen at 0° and 760^{mm} by the reduced volume of air in the companion tube, and is a constant which can be used as long as the companion tube lasts. In practice, a companion tube filled with mercury will last with a little care for a very long time. Even when filled with water I have found that excellent results may be obtained, and that the tube will last for some weeks. Williamson and Russell, in their processes for gas analysis, have employed a companion tube for bringing a gas to be measured to a constant pressure, but the application made above is, I believe, wholly new.

2. *On the application of Sprengel's mercurial pump in analysis.*



The first application of Sprengel's pump in analysis is unquestionably due to Frankland, who, in a paper on the analysis of potable waters, describes an advantageous form of the apparatus, together with a method of determining with it small quantities of nitrogen. Frankland's paper came into my hands after I had myself made a similar application of the pump, and had executed several organic analyses by its aid. As the instrument has now been nearly two years in use in my Laboratory, I will here give the results of my experience. The pump I use differs in several particulars from that of Frankland. Repeated fractures of the glass soon showed the necessity of making the tube as flexible as possible. I therefore introduced into the vertical or descent tube, three joints, and substituted a T tube of iron for the glass T, which I at first employed. The horizontal branch of the pump is connected directly with the combustion tube by means of a good stopper of vulcanized rubber previously wet and forced into the tube as tightly as possible. The annexed wood cut will give a correct idea of the whole apparatus, and for any one familiar with the principle of the pump, will need no explanation. The joints *a* and *b* are made of good vulcanized rubber tightly wound with iron wire. Round each of these is placed a larger tube of vulcanized rubber tied above and below and filled with mercury. The ends of the iron T tube A are protected in a similar manner, the glass tube being cemented into the iron. The lower joint *c* is more simple, and has no exterior tube. It consists of thick vulcanized rubber covered on the outside with a varnish, suggested to me by Prof. Crafts, and consisting of a mixture of pitch, gutta percha and wax melted together. A strong steel screw clamp *k* serves to regulate the flow of the mercury in the pump tube, the diameter of which is about 1½ millimeters. The mercury reservoir M consists simply of a large green glass bottle, with the bottom cut off, inverted and provided with a good stopper of vulcanized rubber, through which the upper part of the pump tube passes.

The use of this apparatus in absolute determinations of nitrogen is as follows: The substance to be analyzed is mixed in a rather short combustion tube with chromate of lead and a small proportion, five or six grams, of chromate of suboxyd of mercury. The anterior portion of the tube is then nearly filled with freshly reduced, finely divided metallic copper, in front of which a few grams of carbonate of manganese is placed. The connection with the pump being made, the apparatus is first tested by running the pump for a few minutes and allowing the whole to stand for a short time, to see if the level of the mercury in the pump tube remains unchanged. The combustion tube is then to be completely pumped out—an operation which requires from five to ten minutes only—after which the carbonate of manganese is to be cautiously heated until a sufficient quantity of carbonic acid is evolved to completely fill the apparatus and restore the equilibrium of pressure within and without. The combustion is then conducted in the usual manner, care being taken to keep the column of metallic copper at a full red heat, and to proceed slowly. When the combustion is finished, the pump is again set in operation until a perfect vacuum is obtained. The receiver which I employ for collecting the gas, is that of Simpson. It is first filled with mercury; afterwards about fifty cubic centimeters of a solution of caustic potash, of density 1·2, are introduced to absorb the carbonic acid. The nitrogen is then to be transferred to a eudiometer tube and measured. The following analyses will serve to show the degree of accuracy attainable by this process:

0·1380 gr. crystallized asparagin gave 21·98 c.c. nitrogen (moist) at 13°·75 and 759·6^{mm}=18·69 per cent. The formula requires 18·66 per cent.

0·2910 gr. sodic stryphnate gave 125·86 c.c. nitrogen at 18° C. and 559^{mm}=36·28 per cent. nitrogen. The formula $Na(C_4H_2H_5\Theta_2)+H_2\Theta$ requires 36·26 per cent.

0·8593 gr. potassic oxalurate gave 115 c.c. nitrogen at 6°·25 C. and 762·7^{mm} =16·50 per cent. The formula $KC_3H_3N_2\Theta_4$ requires 16·47 per cent.

0·6730 gr. allantoin gave 189 c.c. nitrogen at −1° C. and 761·5^{mm} =35·40 per cent. The formula $C_4H_6N_4\Theta_3$ requires 35·40 per cent.

In working with Sprengel's pump in the manner indicated, many observations of practical value have been obtained. In the first place it has been clearly shown that the products of combustion executed in vacuo frequently differ in a remarkable manner from those conducted under ordinary atmospheric pressure. Thus ammonic nitrate at common pressures is decomposed by heat with simple resolution into nitrous oxyd and water. But in the nearly perfect vacuum produced by the mercurial pump, the reaction is entirely different, very large quantities of red nitrous or hyponitric vapors being evolved. In like manner Mr. Sharples has observed that cupric oxalate, which is usually decomposed by heat into carbonic acid and metallic copper, in vacuo always yields more or less carbonic oxyd. Gunpowder burns slowly and without explosion in vacuo—an observation which, however, is by no means new—but gun cotton explodes as violently as in air.

In my first experiments, in which I attempted to collect nitrogen by conducting the analysis without previously filling the apparatus with carbonic acid, I almost invariably found that a considerable quantity of oxyd of nitrogen—chiefly NΘ—was mixed with the nitrogen collected. In addition it was extremely difficult to bring the analysis to a successful termination, because the pressure of the atmosphere often compressed the anterior portion of the combustion tube into a solid mass. I at first used cupric oxalate to furnish the required carbonic acid, but this was soon rejected for the reason given above, and I fell back upon magnesite or manganous carbonate. When the first successful experiments in determining nitrogen had been made, I was sanguine of being able to determine both nitrogen and carbonic acid in an organic body by a single analysis in which the gases should be collected and measured together, the carbonic acid being afterwards absorbed by potash. In this, however, I failed entirely on account of the compression of the combustion tube alluded to above, when the combustion is made in vacuo. I also attempted to absorb the carbonic acid by means of a tube filled with soda lime, as recommended by Mulder, but without success, the absorption being always incomplete.

Mr. Sharples has been more successful in determining nitrogen and hydrogen by a single analysis. By placing a weighed chlorid of calcium tube in front of the combustion tube, he has found it possible to determine the water formed in the combustion directly by weight, and at the same time to collect the nitrogen with all requisite accuracy. In this manner 1·3285 gr. of asparagin gave 0·8028 gr. water=6·71 per cent. hydrogen and 222·75 c.c. nitrogen at 15°·5 C. and 734^{mm}=18·66 per cent. The formula requires 18·66 per cent nitrogen and 6·66 per cent hydrogen.

It can hardly be doubted that further improvements in the process will render it possible to determine in a single analysis, carbon, hydrogen and nitrogen with greater facility and accuracy than nitrogen alone can be determined by the older methods. In conclusion I may state that the Sprengel pump may be applied with great advantage to the determination of the amount of gas given off from various substances by the simple application of heat.

ART. XLV.—*On a peculiar form of the discharge between the Poles of the Electrical Machine;* by ARTHUR W. WRIGHT, Prof. of Physics and Chemistry in Williams College.

WHEN the Holtz electrical machine is working at a high tension, but without the condenser, if the distance between the poles be gradually increased, the discharge successively varies from the ordinary spark of an inch or two in length to a diffuse, much branched, and feebly luminous spark, which under high tension may attain a length of several inches, though it gives but a slight detonation. If the interpolar space be still further widened, either the discharge becomes finally silent, or, more commonly, one or more small jets or brushes issue from the negative pole, with a hissing or fizzing sound, if the discharge is very energetic. When this is the case the positive pole is covered with a diffuse glow, resembling that of a phosphorescent substance, or rather, so thin is the luminous stratum, the pole appears as if it were *illuminated* by a light shining from the direction of the opposite pole. The polar interval, under which the glow appears to best advantage, varies somewhat with the condition of the atmosphere, but, with the machine used in these experiments (a Holtz machine with 20-inch revolving disk), extends from three or four to seven or eight inches, depending also to a certain degree upon the tension of the machine.

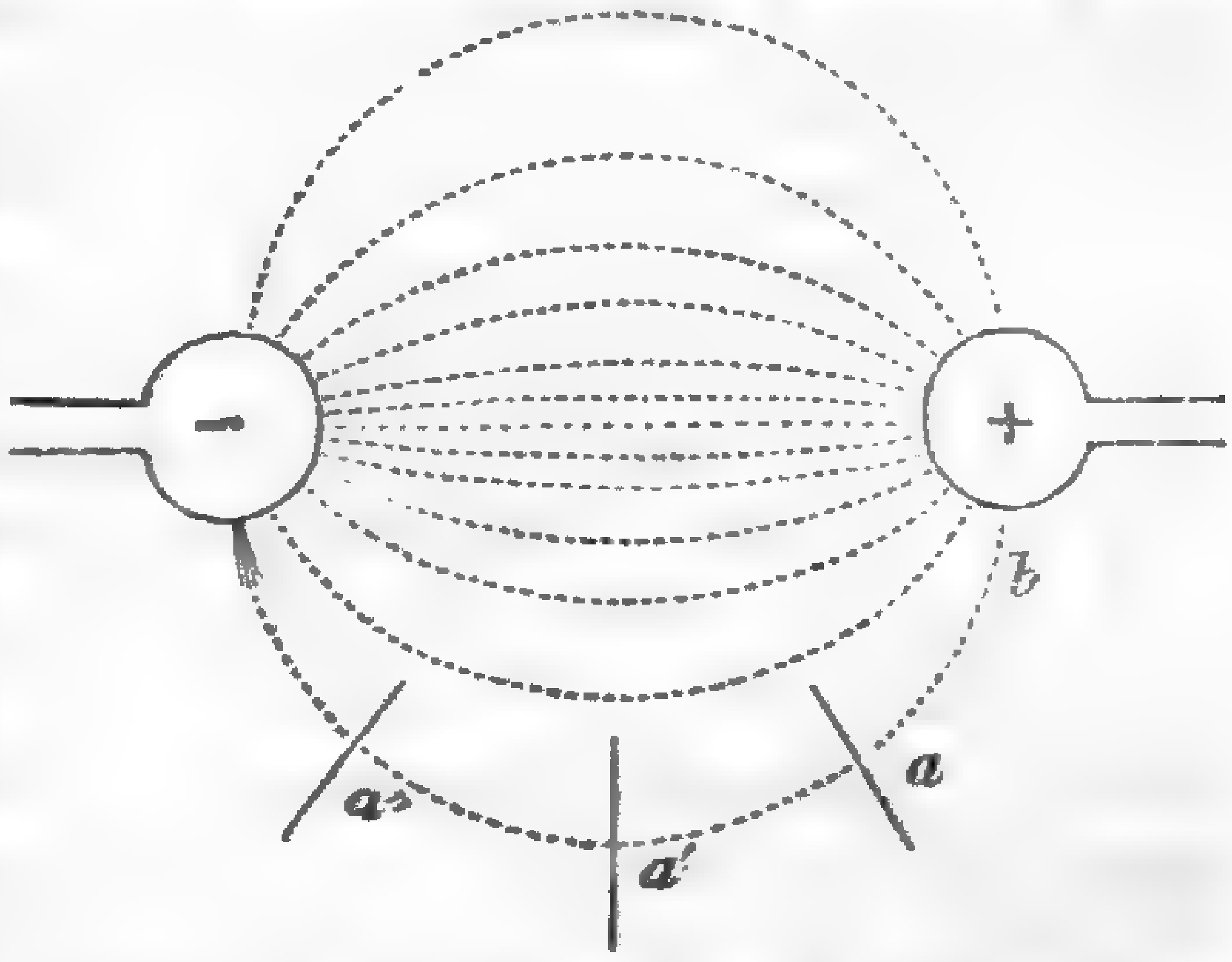
If now the finger or some other object be interposed between the poles, the glow is interrupted, and a silhouette of the object is formed upon the brass ball, which strongly resembles the shadow cast by the body when placed in a beam of luminous rays, moving as the body moves, expanding and contracting as the distance varies, and the like. So striking is the resemblance of this appearance, which may be called an *electrical shadow*, to a real shadow, that I had many times noticed it casually, when using the machine in a dimly lighted room, without suspecting that it was not actually a shadow due to light reflected from objects in the room upon the ball, and it was only when the experiments were made in a room completely darkened that its different character became clearly apparent.

The experiment succeeds best when the air is not too humid, and a single jet issues quietly from the negative. With a little care and after a few trials the shadows can be obtained with great distinctness and remarkable regularity. It is better in general to use for the interposed body some non-conducting substance, or an imperfect conductor, like paper, or wood, as when metallic objects are used they become electrified by induction, and disturb the regularity of the phenomena, or, when the tension is very high, cause the passage of diffuse sparks and brushes. With proper care, however, good results can be got with metals, though usually for much smaller polar intervals than with poor conductors.

In order to ascertain with how great accuracy of detail the figures are formed, a piece of wire gauze was used, the meshes of which were about $2{\cdot}5^{\mathrm{mm.}}$, and the wires forming them about $1^{\mathrm{mm.}}$ in diameter. The poles being separated about four and a half or five inches, the shadows were formed with striking distinctness, even where the gauze was two inches distant from the positive pole, growing smaller and smaller as it receded. Every peculiarity of the texture was faithfully represented, the irregularities of the wires, breaks in the gauze, and the like, being accurately reproduced, and moving with the gauze, just as in the case of true optical shadows. With a piece of still finer wire-cloth, the meshes of which were about $1{\cdot}3^{\mathrm{mm.}}$, similar results were obtained, the distances, however, being smaller than in the previous case. When the gauze was an inch or an inch and a half from the positive, the meshes in the shadow were seen with some difficulty on account of the feeble illumination, but still appeared quite well formed and regular. Their size could not readily be ascertained by measurement, but they were estimated at from one-third to one-half a millimeter in diameter.

More interesting and varied results were obtained with a grating made of common writing paper by cutting out square apertures about $3^{\mathrm{mm.}}$ in diameter, and the same distance apart. The piece used contained twenty-five such apertures, arranged in the form of a square with five on a side. Shadows of great sharpness and accuracy were obtained with ease even when the poles were seven or eight inches apart. As the paper was moved toward the positive side they grew smaller, and again enlarged as it approached the negative, becoming, however, somewhat indistinct when nearer the latter. When the negative jet and the center of the grating were in the line joining the two poles, the images were formed symmetrically about the vertex of the positive pole. The corner apertures in this case being more distant from the axis, had their images somewhat distorted, so that the sides of the square were represented by lines curved in such a way as to make the angles at the corners acute, just as it would happen if the square should be stretched in the direction of its diagonals.

Very frequently, in fact usually, the jet does not issue from the vertex of the negative, but is displaced to the one side or the other. In such cases the glow is also displaced in a similar manner, that is, so that its axis is inclined at an equal angle to the line between the poles with that of the negative jet. If the grating is placed before the latter, and perpendicular to it, the shadows are still formed as before, though not in general quite as perfectly. Thus if placed at *a*, as in the cut, the image appears at *b*. On moving it away from the pole to a position represented by *a′* the image still appears at *b*, but is larger, and so on at *a″*, or until it is brought within an inch or two of the negative. In this way the lines traversed by the electricity, or along which it acts, may be readily traced, and they are found to have a conformation similar in some respects to that of the voltaic arc, but far more regular and symmetrical. In their general character they are represented by the dotted lines in the cut. Issuing normally from some point of one of the poles, a line passes in a curve to the homologous point on the other pole, where also it meets the surface normally. When the jet is not far from perpendicular to the line of the poles, the curve may have an amplitude of nearly or quite half the distance between the latter, even when these are eight inches, or more, apart.



An interesting case occurs when the negative discharge takes the form of a ring. The glow likewise assumes the form of a narrow and sharply defined ring, whose size and position of course depend upon those of the other ring. The approach of any intercepting or disturbing body either breaks or bends the luminous line, and this affords, perhaps, the best means of determining the form of the curves between the poles, as the limits where the disturbance begins are pretty definitely marked, and their position can be readily determined by measurements. An easy way to secure a steady and well-defined ring, is to place upon the negative pole, first removing the ball, a common bottle cork an inch or two in diameter, well shaped and carefully smoothed, with the larger face towards the positive pole, and perpendicular to the polar axis. On putting the machine in action, the electricity issues from the sharp edge of the cork in the form of a regular and steady fringe-like ring, the radial elements of which stand at a nearly constant angle with the axis. A beautifully distinct ring is thus formed upon the opposite pole.

Comparing the forms of the curves indicated by the above experiments with the ordinary sparks and brushes, or even with the voltaic arc, a striking difference in respect to symmetry and constancy is observed; and the distinctness and beauty of some of the phenomena are very remarkable, especially when it is considered how lawless and irregular the ordinary spark and brush discharges are as to form. The glow, like the brush, is obviously caused by the discharge of electricity at the positive pole, and apparently a discharge from one pole to the other takes place, silently and without luminous effect, through or by means of the intervening air. But that the lines along which it takes place should be so constant and regular is somewhat surprising. It is to be observed that the perfection of the results depends to a considerable degree upon the condition of the air, as when this is too moist, the discharge is not sufficiently energetic, or the resistance is not sufficiently great, to bring out the glow, or to form the images with distinctness.

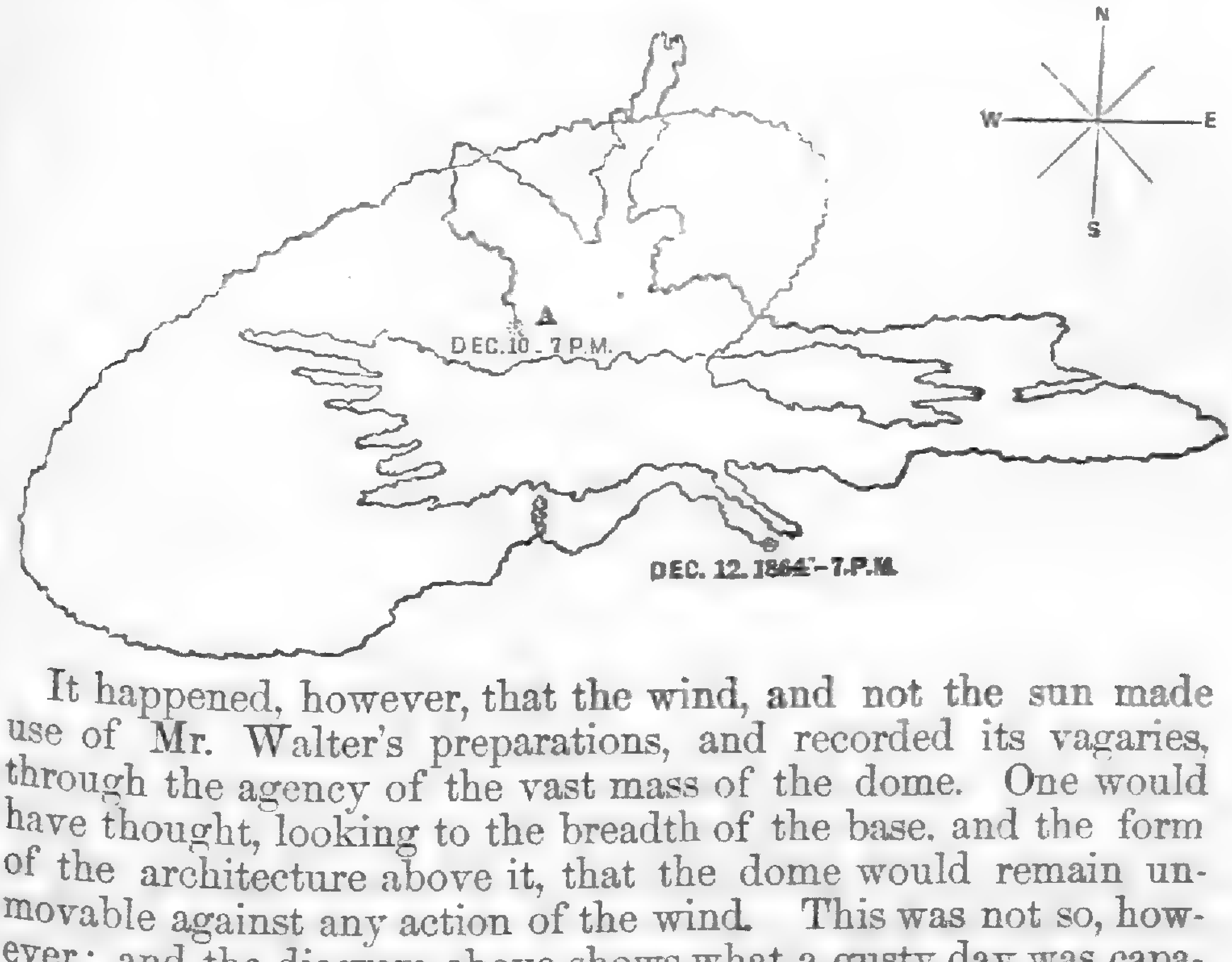
Williamstown, Mass., April 5, 1870.

ART. XLVI.—*Movement of the Dome of the Capitol at Washington, during the gale of December* 10–12, 1869. From a letter to the editors.

WE all know, by having seen the thing itself, or representations of it, the form of the dome of the capitol at Washington. It is of cast and wrought iron throughout. Its architectural beauty is only equaled by the truly wonderful combinations of its multitudinous parts. Had it been erected at any other time than during the late war, when men's views were absorbed in watching the vicissitudes of the contest, it would have attracted the eager attention of hundreds of scientific observers, who would have noticed, with the deepest interest, the ingenuity and skill with which all the exigencies of the structure were provided for, until a rail road, built, as it were, in the skies, was used to place the statue on the summit.

The exterior diameter of the dome, where the iron work rests, as it were, on the roof of the building, is somewhere about one hundred and thirty-seven feet; and the height, from the roof to the feet of the statue about two hundred—the statue is between nineteen and twenty feet high.

The distinguished architect, Mr. Thomas M. Walter, supposed naturally enough, that this enormous amount of iron would be more or less affected by the action of the sun's rays—causing an expansion, to meet which he had been making, throughout his protracted labors, all possible provision. To ascertain what this effect would be, he suspended a wire from the center of the ceiling of the Tholus, or crowning cupola, under the feet of the statue. At the extremity of this wire nearest the ground, or pavement of the rotunda, he arranged a delicate mechanism, that carried a pencil, whose point rested on a sheet of paper, on which it was expected that expansion and contraction would record their effects. It was Mr. Walter's expectation, probably, that, as the sun moved from the east to the west, something of a uniform curve would be traced by the pencil's point upon the paper, furnishing, in that way, data that might be as useful as they would be original.



It happened, however, that the wind, and not the sun made use of Mr. Walter's preparations, and recorded its vagaries, through the agency of the vast mass of the dome. One would have thought, looking to the breadth of the base, and the form of the architecture above it, that the dome would remain unmovable against any action of the wind. This was not so, however; and the diagram above shows what a gusty day was capable of effecting, in giving motion to the mass. Beginning at A, and following the lines, it can be seen when the wind blew fitfully but moderately, and then, when a blast of unusual violence occurred; and when, too, the direction was changed, as the wind veered round the points of the compass. That chimneys and shot towers wave in the wind is well known; but the movements that take place in rough weather in the dome of the capitol could hardly have been reasonably expected.

The diagram above is a tracing carefully made from the work done by the pencil on the occasion now referred to. L.

I. PHYSICS AND CHEMISTRY.

1. *On the heat of combination of boron with chlorine and oxygen.*—Troost and Hautefeuille have communicated to the Academy of Sciences a memoir on the heat of combustion of boron, a subject which we believe has not hitherto received attention but which the rapidly increasing importance of thermo-chemistry invests with great interest. The authors employed in their investigations the muffle calorimeter of Favre. Dry chlorine was allowed to act upon amorphous boron placed in the muffle, the chlorid of boron formed being condensed in the water of the calorimeter. The heat measured was thus the sum of the heat of combustion proper and of the heat evolved in the combination or double decomposition of the chlorid with water. The heat due to the last mentioned reaction was then determined by a special experiment. In this manner the authors obtained as a mean of 6 experiments 104000 units of heat developed in the combination of one atom of boron with three atoms of chlorine, and 79200 units of heat disengaged by the reaction of one atom of boric chlorid, BCl_3, with 140 times its weight of water. From the heat developed in the last case the authors deduced the heat of combination of boron and oxygen by subtracting first the heat due to the formation of three equivalents of chlorhydric acid as determined by Favre, and secondly the heat produced by dissolving an equivalent quantity of boric acid in an equal weight of chlorhydric acid of the same degree of dilution, as determined by direct experiment. In this manner the heat of combustion of boron in oxygen was found to be 158600 units for one equivalent (old style) of boron. The boron employed was in the amorphous modification; the authors promise similar determinations for the other forms of this element.—*Comptes Rendus*, lxx, 185. W. G.

2. *On the heat of combination of silicon with chlorine and oxygen.*—The same authors in a second communication have given a determination of the heat of combustion of silicon with chlorine and oxygen. To effect the union of chlorine with amorphous silicon it was found necessary to mix the silicon with $\frac{1}{10}$ of its weight of boron, the heat of combination of which was of course subtracted. The mode of experimenting and the corrections were the same as in the case of boron described above. It was found that one equivalent of chlorid of silicon acting upon 140 times its weight of water disengages 40825 units of heat and that one gram of silicon in burning in chlorine evolves 5630 units, which amounts to 78820 units for one equivalent (Si=14), or to 118230 units for one equivalent (Si=21). By a process exactly analogous to that employed in the case of boron the authors found for the heat of combination of silicon and oxygen 7830 units per gram, which amounts to 109620 units per equivalent (Si=14) or 164430 units for Si=21. In addition the heat of transformation of amorphous into crystalline silicon was determined by dissolving the different varieties of silicon in nitro-fluohydric acid and thus obtain-

ing the difference in the quantities of heat disengaged by their oxydation. In this manner it was found that amorphous silicon in becoming crystalline evolves 290 units of heat per gram, or 4060 per equivalent ($Si=14$).—*Comptes Rendus*, lxx, 252. W. G.

3. *On some remarkable spectra of compounds of zirconium and the oxyds of uranium.*—Mr. SORBY has found that the remarkable absorption bands exhibited by certain specimens of zircon and which he had attributed to the presence of a new metal—Jargonium—are in reality due to uranium, which, under certain circumstances, gives bands of a very remarkable character wholly unlike those yielded by the ordinary salts of the metal. Thus the salts of uranium usually exhibit a variable but small number of moderately broad absorption bands at the *blue* end of the spectrum, while the zircons exhibit numerous narrow black lines, fourteen of which are quite distinct, together with other fainter lines and a broad black band extending from the *red* end, so that nearly all occur in that part of the spectrum which is entirely free from bands in the other uranic compounds. Mr. Sorby has detected in some zircons erbium, didymium, yttrium and another substance which exists in such small quantity that the author has not been able to decide whether it is a new earth or not. In fact the spectral analysis in this case fails to give any decisive evidence, since some other known oxyd may give with zirconia a spectrum as abnormal as that produced by the presence of a trace of uranium. There is therefore at present no evidence that zircons contain any new metallic oxyd.—*Chemical News, Feb.* 18, 1870. W. G.

4. *On the dissociation of ammoniacal compounds.*—In investigating the dissociation of ammoniacal compounds ISAMBERT has found that the tension of the ammonia evolved is constant at a given temperature and increases progressively with it. The author obtains the anhydrous ammonia-sulphates of zinc, cadmium, &c., by passing a current of ammonia for several hours over the salt, which swells up, becomes hot and falls to powder. The ammonia-sulphates of zinc and cadmium thus formed correspond respectively to the formulas $ZnSO_4+10NH_3$ and $CdSO_4+6NH_3$. In like manner calcic and strontic chlorids unite with ammonia to form $CaCl_2+8NH_3$ and $SrCl_2+6NH_3$; hot boric chlorid does not unite with ammonia. By heating the compound formed in vacuo, the tension of the ammonia may be measured. Cadmic sulphate gave the following results, care being taken after each experiment to expel the gas which fills the apparatus:

Temperatures.	Tensions.
48°·5	368^{mm}
51°·5	439^{mm}
100° (mean of 6)	$1366{\cdot}3^{mm}$

The salt remaining in the tube consisted of $CdSO_4+2NH_3$ and gave off no more ammonia at 100°. The author infers that the cadmic salt should be regarded as $(CdSO_4 2NH_3)4NH_3$ and finally that the pulverulent compounds formed always absorb a little ammonia mechanically, so that the tensions do not become constant until only the combined gas remains. The general results of this investigation agree with those which the author had previously obtained with the ammonia-chlorids. Lamy has based the construction of a new thermometer upon the tension of the ammonia evolved in heating the ammonia-chlorids and especially that of calcium. Between 0° and 46° the tension increases from 120 to 1431 millimeters, and will therefore give an extremely delicate measure of increments of temperature.—*Comptes Rendus*, lxx, p. 456 and p. 393.

W. G.

5. *On a new method for the synthesis of organic acids.*—BERTHELOT has found that the hydrocarbons of the acetylene series are capable in the presence of alkalies of uniting directly with water, oxygen and the alkaline base to form acetic acid and its homologues. Thus in the case of acetic acid we have,

$$C_2H_2+O+H_2O=C_2H_4O_2.$$

Acetylene may be converted with acetic acid more completely by means of pure chromic acid, the action of which, according to Berthelot, is different from that of a mixture of potassic bichromate and sulphuric acid, and much more moderate. Thus chromic acid converts ethylene into aldehyd, propylene into acetone and camphene into camphor, which reactions are not effected by sulphuric acid and the bichromate which act too powerfully. Pure chromic acid acts on the carburets at ordinary temperatures and its action may be increased by heat or moderated by dilution. Allylene under the same circumstances of oxydation yields propionic acid. Propylene, C_3H_6, yields propionic acid, acetic acid and acetone, the propionic acid being probably derived from propionic aldehyd, isomeric with acetone. Chromic acid even attacks carbon in the cold. By operating with pure carbon Berthelot succeeded in obtaining a small quantity of oxalic acid,

$$2C+3O+H_2O=C_2H_2O_4.$$

The oxydation of allylene by means of chromic acid appears first to yield an aldehyd C_3H_4O, which then by taking up the elements of water becomes propionic acid. The author sums up his results as follows:

1. A first oxydation gives oxygen by simple addition, with formation of an aldehyd or acetone:

thus $C_2H_4+O=C_2H_4O$ (aldehyd)

$C_3H_6+O=C_3H_6O$ (acetone and propionic acid.

2. A further action—always on the free hydrocarbon—generates monobasic acids;

$$C_2H_4+O+H_2O=C_2H_4O_2$$
$$C_3H_4+O+H_2O=C_3H_6O_2.$$

3. Finally, as already shown, the same hydrocarbons by the action of the alkaline hypermanganates yield bibasic acids:

$$C_2H_4+2O=C_2H_4O_4$$
$$C_3H_4+2O_2=C_3H_4O_4.$$

Thus the direct and regular oxydation of the hydrocarbons yield successively aldehyds, monobasic acids and bibasic acids.—*Comptes Rendus*, lxx, 256. W. G.

6. *On the Ethyl compounds of Thallium.*—HANSEN has succeeded in replacing two atoms of chlorine in thallic terchlorid by ethyl and obtaining the chlorid of thallium-diethyl with corresponding oxygen salts. When thallous chlorid, TlCl, is suspended in ether and a current of dry chlorine gas is passed in, a yellow fuming liquid is obtained which becomes brown in the air. Zinc-ethyl acts powerfully on this liquid with strong evolution of heat—and when an ethereal solution of zinc-ethyl is mixed with one of thallic terchlorid and the product of the reaction shaken with dilute chlorhydric acid a white curdy crystalline mass is obtained after the distillation of the ether which after purification is the chlorid of thallium diethyl, $Tl(C_2H_5)_2Cl$. The new chlorid is soluble in hot water, ether and alcohol and crystallizes in silky scales. It blackens in the light like argentic chlorid—a property which it also according to the author—shares with thallous chlorid. When suddenly heated it explodes with formation of thallous chlorid and a gas, which is a mixture of ethylene and ethyl-hydrid so that we have

$$Tl(C_2H_5)_2Cl = TlCl + C_2H_4 + C_2H_6.$$

By double decomposition with argentic sulphate and nitrate the author obtained the sulphate, $[Tl(C_2H_5)_2]_2S\Theta_4$, and the nitrate $Tl(C_2H_5)_2N\Theta_3$ which crystallize in leaves and are soluble in water, alcohol and ether. The author promises a further investigation of this very interesting and theoretically important subject. —*Berichte der Deutschen chemischen Gesellschaft*, No. 1, 1870, p. 9. W. G.

7. *Spectrum Analysis: Six Lectures delivered in* 1868 *before the Society of Apothecaries of London.* By HENRY E. ROSCOE. London. C. Macmillan & Co.—We are indebted to the kindness of the author for a copy of this work, which presents the most complete account of the history and development of spectral analysis to be found in any language, if we except perhaps the German treatise of Schellen and the Swedish work of Thalen.* The six lectures form rather less than half the work. They are simply and agreeably written, not too popular, nor yet too abstruse for a popular work in the best sense of the term. Their value is greatly increased however, for the scientific reader, by the addition of numerous and elaborate appendices including in many cases entire memoirs. Besides the diagrams and figures which illustrate the lectures, the work is enriched by an excellent lithographic reproduction of Kirchhoff's chart from A to G and of Angström's and Thalen's chart from G to H, and with chromo-lithographs of the spectra of several fixed stars and nebulæ. Kirchhoff's and Huggins' tables are given in full. The results of the analysis of the light of the sun's atmosphere up to the date of the publication of the lectures are also given.

* Om Spektral analys. Upsala Universitets Arsckrift, 1866.

Finally there is an excellent bibliography of works and memoirs on the spectroscope and spectral analysis. That the work should not in every respect deserve unqualified praise will seem natural enough, yet we are not disposed to find fault with so rich a store of information offered to us in so acceptable a form. W. G.

II. MINERALOGY AND GEOLOGY.

1. *On the Megadactylus polyzelus of Hitchcock;* by E. D. Cope.—This genus was named by Hitchcock in his Supplement to the Ichnology of New England, p. 39, 1865; the bones have been briefly described in his Ichnology on page 186. The remains were found in a more or less fragmentary condition in the red sandstone rocks of the Valley of the Connecticut, from the neighborhood of Springfield, Massachusetts. They were found by William Smith, while engaged in superintending some excavations made at the armory, which required blasting.

The remains consist of four caudal and one dorsal vertebræ, the greater part of the left fore foot, with distal portions of ulna and radius; the greater part of the left femur, proximal end of left tibia, greater part of left fibula, tarsus and hind foot, including a tarsal bone, perfect metatarsus, proximal end of a second metatarsus, parts of the distal end of a third, and parts and impressions of four phalanges.

These fragments demonstrate the former existence in the region in question of a typical form of the suborder or order Symphypoda (*Compsognatha* Huxley), and one nearer the birds than any other hitherto found in America. Its pertinence to this order is shown by the absence of the first series of tarsal bones, apparently, as Gegenbaur has suggested, and as the structure of Lælaps proves, in consequence of their confluence with the distal extremities of the tibia and fibula. This important character is apparently assumed early in life in the present genus, and in Compsognathus, and probably quite late, in Ornithotarsus. In Compsognathus the additional peculiarity of the persistence of but two carpal bones is presented, which, according to Gegenbaur, should correspond with those of the first row of ordinary Reptilia, while those of the second have disappeared. In Megadactylus those of the first series are present, viz: the radiale and probably ulnare, and one of the second row, very much reduced, opposite to the second metacarpus. There is space for a second one of the second series, but it does not appear in the matrix, while the ulnare is probably lost.

The bird-like tendencies of the Symphypoda have been indicated above, and the very ornithic character of the bones of the present form is also very marked. The walls of the long bones are very thin, in some places near their extremities almost as much so as writing paper. The vertebræ and ischia present the same thin walls. The structure of these walls is exceedingly dense.

Prof. Cope next gives the special characters of the bones, which are here omitted. He adds:

That animals of this genus made some of the tracks similar to those of birds in the red sandstones of the Valley of the Connecticut there can be no doubt. It furthermore explains some problematical impressions which are occasionally found with them. Tracks of an animal resting in a plantigrade position, as indicated by the moulds of two long parallel metatarsi, each terminated by three toes, are accompanied by a peculiar, bilobate, transversely oval mark on the middle line, some distance behind the heels.

Prof. Hitchcock states that it appears to be the impression of a short stiff tail. The present specimen shows clearly that it was made by the obtuse extremities of the ischia. The saurian squatted down, resting on its styloid ischia as the third leg of a tripod of which the anterior pair was represented by the hinder legs. Prof. O. C. Marsh informs me that in the museum of Yale College, a slab exhibiting impressions similar to the above shows the impressions of the anterior feet also, which were put to the ground in the act of rising or sitting, or perhaps reached to it while the animal was squatting, as do those of carnivorous Mammalia.

The tracks of many of the animals discovered by Hitchcock are plantigrade. That they could not have walked like the plantigrade mammal, is sufficiently evident from the length of the metatarsal elements, which would necessitate a constant contraction of the tibialis anticus muscle, or peculiar arrangement of the tarsal bones, for its support. The latter does not appear to have existed, and the former is so very improbable, that, in connection with the pneumatic structure of the bones, there is abundant reason to suppose that they progressed by leaps, and assumed the plantigrade position when at rest.

No portion of the cranium or dentition of this genus has been preserved. The large stout hooked claws of the fore foot would indicate a more or less carnivorous diet.

The existence of Symphypoda in the strata here indicated, with the occurrence of a Pterosaurian in a similar situation in Pennsylvania, points to the existence of the transition from Keuper to Lias, that is, from Triassic to Jurassic beds, in the red sandstones of eastern United States. They have been heretofore regarded as Triassic,* which the lower portions of them undoubtedly are, and similar to the German Keuper in the presence of Labyrinthodonts, Thecodonts and Dinosauria in both Pennsylvania and N. Carolina.

The remains here described were alluded to by Prof. R. Owen, as those of a Saurian pointing to the Pterodactyles or Birds, providing the cavities of the bones were filled by marrow, and not by cartilage. Prof. Wyman regarded them as those of a reptile, though the long bones might have been referred to a bird if considered alone. "While the bones from Springfield are as hollow as those of the Pterodactyle, I do not find that they are those of this animal; there is no positive proof of the long fingers nor of

* Hitchcock, in his Ichnology (1858), holds that the beds containing the tracks are lower Jurassic, either Oolitic or Lias; and Dana, in his Geology, (pp. 414. 443), says that the so-called Triassic is probably in part Jurassic.—EDS. AM. J. SCI.

the broad sternum which these reptiles possessed. The existence of the large toe in company with the small one is in favor of a jumping animal."—*From the Memoir of Prof. Cope on Extinct Reptilia and Aves, Amer. Phil. Soc., unpublished volume.*

2. *On the Elasmosaurus platyurus of Cope;* by Dr. J. LEIDY. (Communicated by the Author).—At a meeting of the Academy of Natural Sciences of Philadelphia, March 8th, Prof. Leidy stated that after an examination of the remains of the great marine saurian, from the Cretaceous formation of Kansas, presented to the Academy by Dr. T. H. Turner, U. S. A., and described by Prof. Cope under the name of *Elasmosaurus platyurus*, he had arrived at the conclusion that the animal belonged to the Enaliosaurians. It was closely allied to *Plesiosaurus;* the peculiar characteristics of the different regions of the vertebral column, together with those of the shoulder and pelvic girdles, and the fragments of the skull and teeth, are decidedly Plesiosaurian.

Prof. Cope has fallen into the error of describing the skeleton in a reversed position to the true one, and in that view has represented it in a restored condition in his recent "Synopsis of the Extinct Batrachia, Reptilia, and Aves," published in the Transactions of the American Philosophical Society. To explain the apparently anomalous and reversed condition of the articular processes, (zygapophyses) of the vertebræ, he considers that those ordinarily existing in animals are substituted by the second set (zygosphene and zygantrum) of serpents and iguanians.

The discovery of a portion of the skull, as reported by Dr. Turner, in the vicinity of what Prof. Cope regards as the anterior extremity of the skeleton, and which he considers as confirmatory of the view he has taken of the latter, Prof. Leidy remarked, independently of the many anatomical characteristics, is more than compensated by the opposite end of the vertebral column terminating in a coossified axis and atlas, this latter still retaining in its cup the occipital condyle.

A comparison of caudal vertebræ of the Kansas saurian with isolated specimens from the Cretaceous formations of Alabama, Mississippi, and New Jersey, referred by Prof. Leidy to a Plesiosaurian, under the name of *Discosaurus*, leads him to view *Elasmosaurus* as identical with it. Such also appears originally to have been the view of Prof. Cope, in relation to a part of the same skeleton which he referred to a species with the name of *Discosaurus carinatus.*

The restored *Discosaurus* or *Elasmosaurus*, would repeat the form usually given of *Plesiosaurus*, but the neck was of more remarkable length than in the latter. It comprised the almost incredible number of *seventy-two cervicals*, and measured almost twenty-two feet in length, independent of the head. The imperfection of the rest of the vertebral column does not permit anything like a positive estimate to be made of the comparative extent of the trunk and tail.

In the true view of *Discosaurus* or *Elasmosaurus*, Prof. Cope's order of Streptosauridæ fails to maintain its ground.

3. *Ornithopsis, a gigantic animal of the Pterodactyle kind from the Wealden;* by H. G. SEELEY (Ann. Mag. N. H., IV, v, 279).—Under the above title Mr. Seeley describes two vertebræ in the British Museum, one from Tilgate and the other from the Isle of Wight, which "are of size and structure and texture such that both might well have belonged to the same kind of organism," and probably the same animal. One vertebra is from the lower part of the neck, and the other from the back; and when perfect the former, from the back to the front of the centrum, could "scarcely have measured less than ten inches." "Seven such vertebræ would have made the neck 4 to 5 feet long, and the animal 10 to 12 feet," while, according to the author, it may have been two or three times as high. The vertebræ are constructed after "the lightest and airiest plan" peculiar to Pterodactyls and birds; they have pneumatic foramina as in these species, and these are very large, like those of the former species. The animal must therefore have been decidedly ornithoid; and the gigantic ornithic foot-prints of the Wealden, described by Mr. Beccles and Mr. Tyler, may have been its tracks. The author closes his paper with naming the species *Ornithopsis Hulkei*, after Dr. Hulke.

4. *Volcanic action on Hawaii;* copy of a letter from Rev. TITUS COAN to Prof. Chester S. Lyman, dated Jan. 24, 1870.—"Our volcanic craters have not made great demonstrations of late, and yet are not quiet. Slight shocks of earthquakes often occur, sometimes one, two or three in a day. During the first two weeks of the present month a good deal of steam and smoke arose from *Mokuaweoweo*, the summit crater of Mauna Loa. In Kilauea the action is fitful. Occasionally the fires rage with much violence, and again they are sluggish. When I was there in August, the old south lake, Halemaumau, was a hundred feet deep, and four-fifths of a mile in diameter on the bottom. On this floor there were eight fiery ovens and orifices open. Since then there have been several vivid overflowings. These, with the slowly acting uplifting forces, have raised the bottom of the crater some 75 feet, so that now the latest facts are that the bottom is within 25 feet of the upper rim, and it is supposed that the pit has been enlarged to more than a mile in diameter. Lord Charles Hervey and Dr. Hans Berag, a Prussian savan, have made two visits there within the past month. They also rode on mules, in company with Judge Hitchcock of Hilo, to the terminal crater of Mauna Loa, and looked into Mokuaweoweo. There was no fire seen, but much steam. These gentlemen took a newly discovered route, which proved much easier than any before known. A cattle ranch has been established at Kapapala, and a milk and butter station is situated a mile higher up the ridge of the mountain. From this upper station the cattle have found their way nearly to the summit, and the herdsmen in search of them have found that mules could reach Wilkes's camp without difficulty. Starting from Kapapala as a 'base of supplies,' you can go nearly to the summit the first day. On the second day you

can ascend to the top, spend several hours, and return to camp to sleep. On the third day you can reach Kapapala ranch before night. It is also now probable that the same could be done from Kilauea as a base."

5. *Geological Map of Canada and the Northern United States;* by Sir W. E. LOGAN.—We have at length the pleasure of announcing the appearance of this important and long looked-for contribution to American geology. Although it bears the date of 1866, its publication has, for some reason, been delayed until 1869. A first copy was shown by Dr. Hunt at the meeting of the American Association at Salem, last summer, and it is only within a few weeks, as we are informed, that the Geological Survey of Canada has been able to procure a small number of colored copies for distribution, one of which is now before us. The legend of the map informs us that the geological details for Canada, comprising the former provinces of Upper and Lower Canada (now Ontario and Quebec) are furnished by the Geological Survey under the direction of Sir William E. Logan. He has himself compiled the geology of the various states of the Union under the supervision of Prof. Hall from various sources which are mentioned in detail in the preface to the Atlas of the Geology of Canada; (published in 1865) where he tells us that this portion of the work was done "with the approval of Prof. James Hall, who has freely placed all his materials at the disposal of the compiler, and aided by his intimate personal knowledge of the geology of a greater part of the region represented." For the geology of the province of New Brunswick, Nova Scotia and Newfoundland, also, the most authentic printed and manuscript maps were consulted, as described in the Atlas just referred to.

An indispensable preliminary to a work of this kind was a correct topographical map, and such a one for Canada had to be slowly and laboriously constructed. The sources of information for this purpose are given at length in the preface already quoted. A series of longitude determinations was made, by electric telegraph, of various points from Chicago to Quebec and Halifax, and both of the latter stations were directly compared with Cambridge. In the absence of a regular trigonometrical survey of the provinces, the U. S. boundary surveys, the lake surveys of the U. S. Topographical Engineers, and the hydrographical surveys of the British Admiralty were available for the course of the St. Lawrence and the British shores, while those of the U. S. Coast Survey were followed for the United States. For the interior of the provinces, in addition to the surveys already existing, great numbers of topographical surveys have been made by the officers of the Geological Survey during the past twenty-five years. From all this material, described in the Atlas, pp. 8–15, it has been possible to make a far more accurate delineation of the geography of the British provinces than has hitherto been attained, and the same remark will apply to the coastal region of the United States, since we believe that this is the first time the beautiful and accurate work of our own Coast Survey has ever been reproduced in a complete form for our shores from the St. Croix to the Chesapeake. The construction of the map was intrusted to Mr. Robert Barlow, formerly of the British Ordnance Survey, and now chief topographer to the Survey of Canada. It has been engraved on steel by Ramboz and Jacobs of Paris, under the superintendence of Mr. Gustave Bossange, and is remarkable for the beauty of its execution. The geological lines having been traced upon the plate, they were placed in the hands of Mr. Stanford, the well known map publisher of London, under whose direction the printing and hand coloring of the map have been executed. The Atlas already referred to contains a small colored geological map, on the scale of 125 miles to the inch, which is a reduction of that now before us, and bears the date of 1864. Changes and additions to the geology have, however, been made in the large map, on which it has been possible also to give the subdivisions of the Quebec group in Eastern Canada, which the small scale of the first map did not allow.

The present map is on the scale of twenty-five miles to the inch, and measures eight feet from east to west by three and a half feet from north to south; extending southward to latitude 37°, and westward to longitude 100°. Its northern limits include the lakes Manitoba and Winnipeg, James's Bay, Newfoundland, and the adjacent Labrador coast, while to the south it takes in Kanzas and northern Virginia.

The geological subdivisions adopted on this map are—1. Laurentian, 2. Labradorian (or Upper Laurentian), 3. Huronian; while for the paleozoic series the names and divisions of the New York survey are essentially adopted, as follows: 4. Potsdam formation, 5. Calciferous, 7. Chazy, 8. Birdseye and Black River, 9. Trenton, 10. Utica, 11. Hudson River, 12. Medina and Oneida, 13. Clinton, 14. Niagara, 15. Guelph, 16. Onondaga or Salina, 17. Lower Helderberg, 18. Corniferous and Oriskany, 19. Hamilton, 20. Chemung and Portage, 21. Old Red sandstone, 22. Lower Carboniferous limestone, 23. Bonaventure (conglomerate), 24. Coal measures, 25. Upper Carboniferous limestone, 26. Permian, 27. Trias, 28. Cretaceous, 29. Tertiary. In the eastern basin, as is well known, the geological survey of Canada admits the existence of a Quebec group, which is regarded as equivalent of the Calciferous and Chazy formations and is divided into three parts in ascending order, viz: the Levis, Lauzon and Sillery formations. These are represented on the map before us; the Levis being colored like the Calciferous, and the Sillery like the Chazy, while the Lauzon (6), is distinguished by a separate color. Add to this two colors for intrusive rocks, one for granites and the other for diorites and dolerites, and we have not less than thirty-one geological divisions, indicated on the map by as many colors. The system of coloring adopted by Sir William Logan is essentially that of the Survey of Great Britain, with such modifications as were required to adapt it to our American geology, and has the merit of bringing into distinct view the great geological divisions without offending the eye by crude and harsh contrasts.

With the exception of the reduction of this in the Atlas, it is believed that no geological map has appeared which presents to the student a connected view of so great an area of the continent. It extends from the Cretaceous and Tertiary rocks of New Jersey, to those of Nebraska and Dakota, and shows at a glance by far the greater part of the wide paleozoic basin of North America. It may at first seem strange that a map designed primarily to display the geology of Canada should be made so comprehensive; but it will be seen that the proposed limits of the New Dominion extend even farther westward than this map, while the southern point of the province of Ontario stretches as far as northern Pennsylvania, or below the 42nd parallel. A clear understanding of the geology of the upper St. Lawrence basin, was, moreover, not possible without a delineation of the great coal fields adjacent, whose relation to Canada, it should be added, is not less important commercially than geologically. These coal fields now furnish large supplies of fuel to the middle and western portions of the Dominion, which, in return, is sending to the coal regions rich ores from its inexhaustible mines of iron,—the commencement of a commerce which must grow in importance, and bind more closely these provinces to our great republic.

On the other hand, we cannot fail to be struck with the extent of the Acadian coal basin, including large portions of Nova Scotia, and New Brunswick, and part of Newfoundland. Out of it, in fact, the Gulf of St. Lawrence has been excavated; and this wide maritime area, with its thick seams of superior bituminous coal, contiguous to safe harbors, and not far removed from the great manufacturing districts of New England, must every year increase in importance alike to the provinces and to the Union. We are tempted to dwell still farther on the great commercial questions raised by the inspection of this geological map, which the geographer, the merchant, and the statesman may consult with equal advantage; but we must confine ourselves to its geological aspects.

For that part of the United States which lies between the Mississippi and the longitude of the Hudson, the geological lines are now so well defined that, except for some parts of the Appalachian belt, no subsequent researches will probably necessitate any considerable change in the map. The geological structure of the provinces of Ontario and Quebec, south of the great Laurentian region which stretches along the north side of the St. Lawrence basin, has been wrought out with an accuracy rarely surpassed, and requires a map on a much larger scale to exhibit it in detail. We have lately seen such a map, about to be published by the Geological Survey of Canada, which, extending from a little west of Montreal to a little east of Quebec, includes the region between that portion of the St. Lawrence and the frontier of the United States. It is engraved on a scale of four miles to the inch, and geologically colored to exhibit in detail the complicated structure of the Canadian extension of the Appalachians, the so-called Notre Dame range. Its publication is delayed by the want of topographical details for some portions, but the map will soon appear, and it is proposed to follow it by the publication of maps of other sections, on the same scale. (See the Atlas, page 23.)

During the three years which have elapsed since the engraving of the present map, considerable progress has been made in investigating the geology of the maritime British provinces. The published reports of Mr. Murray upon Newfoundland show that besides the Laurentian, Potsdam and Quebec rocks of the northwestern portions, extensive developments of Laurentian, Huronian and Primordial Silurian occur towards the southeast, higher rocks, including an area of coal measures, occupying the intermediate portion. This work of Mr. Murray, if continued, will ere long give us a correct notion of the geology of the whole island.

Coming now to the Acadian provinces (Nova Scotia and New Brunswick) much new work has been done, though very much remains to be accomplished there. The map accompanying Dr. Dawson's Acadian Geology (1869) adds something to the present one, and gives a part of the results from the labors of Matthews, Bailey and Hartt. We now know of the existence in New Brunswick, to the south of the coal fields, of considerable developments of Primordial and Upper Silurian rocks, each with a well characterized fauna, and also of a remarkable Devonian flora. A belt near the southern coast of this province, once regarded as of igneous rocks, has been found to belong to an ancient stratified series, probably Huronian, interposed between the Primordial strata and a band of still more ancient rocks, once designated granites, and now recognized as highly crystalline gneisses of Laurentian age. It is probable that the more considerable granite areas now indicated in other parts of New Brunswick will be found, on further examination, to be ancient indigenous rocks as already suggested by Hind and by Dawson, and in part, at least, of Laurentian age. The same remark will apply to Maine and Nova Scotia.

The existence of Laurentian and Huronian rocks to the southeast of the Carboniferous area in Newfoundland and in New Brunswick, and the recent detection by Dr. Hunt of a belt of Laurentian in eastern Massachusetts, leads us to hope that we are approaching to a comprehension of the geological structure of New England. We look for much in this connection from the new geological survey of New Hampshire, under Professor C. H. Hitchcock, and confidently expect that in a second edition of the map before us, which will soon be required, the geology of the New England states will no longer be a partial blank. To the geological student who is familiar with the region, this state of things conveys no reproach. The wide differences in original condition and volume between the sediments of the contiguous western and eastern basins, the comparative rarity of calcareous deposits throughout the paleozoic series in the latter, and its highly altered and crystalline condition, have hitherto presented insuperable difficulties in the way of unravelling the geological structure of this eastern region.

It is to be hoped that the government of the New Dominion will make liberal provision for the distribution of this valuable map. Meanwhile, a geological map, on the same scale and plan, of the southeastern United States is greatly needed to supplement this admirable publication of the Geological Survey of Canada, and we trust that a hand to prepare and means to publish it will not be wanting.

5. *Labradorite Rocks at Marblehead;* by T. Sterry Hunt.—The following note, appended to my paper on Norite Rocks in the last number of this Journal, was accidentally omitted. In speaking of the boulders of labradorite rocks at Marblehead Neck, I said "specimens of this rock, correctly determined and labelled, are found in the collection of the Essex Institute at Salem. To these my attention was called at the time of the meeting in August last, by Prof. C. H. Hitchcock, after which, in company with Dr. G. B. Loring, Prof. Packard and Prof. Kerr, I visited the locality at Marblehead Neck and collected further specimens of the characteristic labradorite rock."

Montreal, March 18, 1870.

6. *Explorations in the Rocky Mountains by J. D. Whitney.*—Professor J. D. Whitney has given the California Academy of Sciences some of the results of explorations under his direction in the Rocky Mountains during the summer vacation of 1869.

The party, which was well provided with instruments for topographical, astronomical, and barometrical work, consisted chiefly of professors and students from the Mining School of Harvard University, and was also accompanied by Professor Brewer, of the Yale Scientific School, and Mr. C. F. Hoffmann, of San Francisco. A careful triangulation was made of the dominating range of the Rocky Mountains between Gray's Peak and the south edge of the South Park, and a map drawn by Mr. Hoffmann, on a scale of two miles to an inch, embracing an area of about 3,500 square miles. This map includes the whole of the South Park and its vicinity; but not the whole of the main divide of the Rocky Mountains, that portion which lies to the northwest of the head of the Arkansas river being necessarily left to be completed at a future time. It is hoped that it will be possible to extend the topographical work to the north and west, so that a detailed map may be prepared of the whole of the highest portion of the Rocky Mountains.

Among the results obtained by this exploration was the determination of the elevation of some high points not previously measured. The highest peak ascended lies to the west of the Arkansas, and it surpasses in elevation any yet observed in the Rocky Mountains. It was named Mount Harvard, and found to be 14,270 feet in height. The next highest points are: Gray's Peak, which was ascertained to be 14,145 feet in elevation; Mount Lincoln, 14,123 feet; and Mount Yale, 14,078 feet. Many other points were measured, but these were the only ones that were found to be over 14,000 feet high.

Dr. Parry is the only other explorer who has published any measurements of the peaks of this region. Having, however, no station barometers nearer than St. Louis, his results are liable to considerable uncertainty, as is shown by the fact that his elevation of Denver was found by the spirit-level surveys of the Central Pacific and Denver roads to be 282 feet too great, a result closely corroborated by the Kansas Pacific Railroad surveys. Dr. Parry also obtained for the height of Gray's Peak a result one hundred feet greater than ours. In every other instance where observations were taken by the Harvard Mining School party at stations previously occupied by Dr. Parry, the results of the latter are found somewhat too high, the discrepancy varying from 50 to 450 feet. This would indicate that the elevation of Pike's Peak, given by Dr. Parry at 14,216, may also be a little too high. But, to obtain the necessary data for working up to the last degree of accuracy the barometrical observations taken in this region, it will be necessary that stations be made on the plains at the base of the mountains—say at Denver—and at some point as high up as possible—as, for instance, Georgetown or Montgomery—and the observations continued for at least one year synchronously at the two stations.

In the meantime, it will be convenient to have the approximate heights of all the points in the Rocky Mountains yet measured, and which exceed 14,000 feet in elevation. They are as follows:

	Feet.
Mount Harvard	14,270
Gray's Peak	14,245 (Parry)
Pike's Peak	14,216 (Parry)
Mount Lincoln	14,123
Mount Yale	14,078
Long's Peak	14,050 (?)

The result here given for Gray's Peak is 100 feet greater than that obtained by the Harvard party. That for Long's Peak is an estimate based on a barometrical observation by Messrs. Powell and Byers, without any corresponding base observation; the barometer stood at 18·100 inches.

From the above it will be seen that no point has yet been found in the Rocky Mountains as high as several in the Sierra Nevada. It will also be noticed as a remarkable coincidence how little the highest points differ from each other in elevation.

It is thought by some that there are still higher peaks than any yet measured to the southwest of Mount Harvard and Mount Yale, in the yet unexplored regions lying between the Arkansas and the Grand. This party was unable to carry its work so far in that direction as would have been necessary in order to decide that point.

The other results of this expedition will be worked out and published in due time.

7. *California Geological Survey.*—All geologists, and all interested in the development of the resources of our country, will rejoice to learn that the resumption of the Geological Survey of California, under Prof. J. D. Whitney, has been ordered by the Legislature of the State. An appropriation of 2,000 dollars per month for two years has been made, "to complete the field work, and publications" Besides this a deficiency appropriation of 25,000 dollars has been passed. The act with reference to this continuance of the survey is entirely satisfactory in all respects. It was chiefly due to the influence and energy of Hon. E. Tompkins, of the Senate, that the Survey bill was carried through both branches of the Legislature by a large majority.

8. *The Geological Survey of Ohio; its Progress in* 1869. Report of an Address delivered to the Legislature of Ohio, Feb. 7th, 1870, by J. S. Newberry, Chief Geologist. 60 pp. 8vo.—Dr. Newberry, the able head of the Geological Survey of Ohio, presents in this report a general review of the organization of the corps for the survey under his charge, his plan and aims, and a brief statement of the geological structure of the State, and the important objects to be secured by the investigations in progress. Some of the results arrived at during the past year have already been mentioned in the last volume of this Journal, at page 417.

9. *Sketches of Creation;* a popular view of some of the grand conclusions of the sciences in reference to the history of matter and of life; together with a statement of the intimations of science respecting the primordial condition and the ultimate destiny of the earth and the solar system; by Alexander Winchell, LL.D., Prof. of Geology, Zoology, and Botany, in the University of Michigan, and Director of the State Geological Survey. 460 pp. 12mo, with many illustrations. New York, 1870. (Harper & Brothers).—The scope of Professor Winchell's work is well made known in its title. It is written for the popular reader; and while its sentences may be regarded as too rhetorical by the scientific student, they may attract others to the subject, and aid many in appreciating the grandeur and bearing of the truths which have been brought to light by geological investigation.

10. *Isomorphism of Gadolinite, Datolite and Euclase.*—Rammelsberg has pointed out in the *Zeitschrift* of the German Geological Society (vol. xxi, p. 807, 1869) the isomorphism of Gadolinite with datolite. He cites the fact that DesCloizeaux has ascertained through optical examination the crystallization of Gadolinite to be monoclinic (Ann. Ch. Ph., IV, xviii); and shows by chemical analyses that the ratio of the oxygen of the silica to that of the bases is 2 : 3 as in the other species above named. The obliquity (or angle C)=89° 28′ and I : I=116°.

Rammelsberg also shows, by a comparison of angles, the isomorphism of Datolite and Euclase. As he does not mention the fact, we add that this isomorphism was announced and proved sixteen years since in this Journal, (II, xvii, 215, 1854), by J. D. Dana, and also in Dana's Mineralogy, 4th ed., 1854, p. 204, where the Euclase group of isomorphs is made to include *Datholite, Euclase, Sphene* and *Zoisite,* to which he soon after (ib., II, xix, 363) added *Keilhauite.* The isomorphism is mentioned also in the last edition of Dana's Mineralogy (1868); and moreover the similarity in chemical composition (which Rammelsberg here exhibits) is there brought out (on pp. 362, 363), both under the new and old system of chemical formulas.

10. *Mineralogical contributions of* G. vom Rath, of Bonn.—In Poggendorf's Annalen, vol. cxxxvi, p. 405, vom Rath has published one of his valuable mineralogical papers, containing the following articles: on the crystallization of Vivianite; the chemical formula of Eulytite (silicate of bismuth), with observations on its crystallization and other characters; on the crystalline form of Atelestite, which he makes monoclinic, with *c* (clinodiagonal) : *b* : *a* (vert.)=0·869 : 1 : 1·822; and *a* on *c*=110° 30′; on the Labradorite of Närödal on the Sognefiord in Norway, with analyses; on the Boulangerite of Silbersand near Mayen, with analyses. For the Eulytite of Schneeberg he found $\dddot{\mathrm{Si}}$ 16·52, $\overline{\mathrm{Bi}}$ 82·23, $\dot{\mathrm{P}}$, $\overline{\mathrm{Fe}}$ 1·15=99·90; again, $\dddot{\mathrm{Si}}$ 15·93, $\overline{\mathrm{Bi}}$ 80·61, $\dot{\mathrm{P}}$ 0·28, $\overline{\mathrm{Fe}}$ 0·52=97·34; whence the formula $\overline{\mathrm{Bi}}^2\dddot{\mathrm{Si}}^3$. This places the species among the Unisilicates.

This paper contains also a notice of a crystalline compound of Zinc and Calcium, corresponding to the formula $Zn^{12}Ca$=Zinc 95·13, Calcium 4·87=100. He found 95·11 and 4·90. Its crystals are small square octahedrons, having the angle of the terminal edges 134½°, and of the basal 66° 18′, whence the vertical axis=0·4619.

11. *Reale Comitato Geologico d'Italia.*—The Italian Government has appointed a Geological corps, for the publication of a large geological chart of Italy, with descriptions of the geological structure of the country. The corps includes Prof. J. Cocchi, of Florence, President, Bartolommeo Gastaldi, Professor of Mineralogy at Turin, F. Giordano, Inspector of the Royal Corps of Mining Engineers, G. Meneghini, Prof. of Geology at Pisa, and Ludovico Pasini, Senator of the Kingdom of Italy; with the assistants Pietro Zezi, Mining Engineer, Giuseppe Grattarola and Angelo Alessandri, Geological Assistants, and Felice Momo, "Aspirante." The 1st and 2d numbers of the Bulletin (Bolletino) were issued in January and February of the present year; and the 1st volume of the Memoirs, to contain papers on Italian Geology, will soon be published. In the February number of the Bulletin, Prof. Cocchi has an abstract of a paper on Elba, and E. Bechi an article on the composition of a dark-colored volcanic rock of Monte Catini containing *mica*, called *Selagite*, (named by Santi *Lava limacciosa micacea*), and also of a prehnitoid rock from the same locality, and of the prehnite of Impruneta. The mica of the selagite was found to consist of

$\dddot{\mathrm{Si}}$ 40·8, $\overline{\mathrm{Al}}$ 22·1, $\overline{\mathrm{Fe}}$ 21·0, $\dot{\mathrm{Mg}}$ 0·5, $\dot{\mathrm{Ca}}$ 5·6, $\dot{\mathrm{K}}$ 5·9, Fl 0·8, $\dot{\mathrm{H}}$ 3·5=100·2.

It has G.=3·15, and H.=2·5. The paste or rock material containing the mica was found to consist of

$\dddot{\mathrm{Si}}$ 44·5, $\overline{\mathrm{Al}}$ 1·7, $\dot{\mathrm{Fe}}$ 37·3, $\dot{\mathrm{Mg}}$ 1·4, $\dot{\mathrm{Ca}}$ 14·0, $\dot{\mathrm{Na}}$, $\dot{\mathrm{K}}$ (*tr*). $\dot{\mathrm{P}}$ 1·1=100. H=4·5, G=2·789.

12. *Gibbsite and Wavellite.*—Hermann (Bull. Soc. Impér. Nat. Moscow, No. 4, 1868, 496), has analyzed a grayish pearly mineral, occurring on limonite, in Chester Co., Pa., in thin crusts, delicately concretionary under a lens. It has a hardness of 3·0, G.=2·35, and is subtranslucent. He obtained

$\bar{\dddot{\rm A}}$l 63·84, $\dot{\rm H}$ 33·45, $\ddot{\rm Si}$ 1·50, $\bar{\dot{\rm P}}$ 0·91, $\dot{\rm Mg}$, $\bar{\dddot{\rm F}}$e *trace*=99·70.

Hermann has obtained for the composition of the Wavellite of the same region (ib.):

$\bar{\dot{\rm P}}$ 32·70, $\bar{\dddot{\rm A}}$l 35·83, $\dot{\rm H}$ 28·39, $\bar{\dddot{\rm F}}$e 3·08, Fl *tr.*=100,

agreeing nearly with the analysis by Genth. He found G.=2·30 and H.=3·5.

The Gibbsite (hydrargillite) of Villa Rica afforded Hermann (ib.): $\bar{\dddot{\rm A}}$l 63·60, $\bar{\dddot{\rm F}}$e 2·00, $\dot{\rm H}$ 34·40=100.

13. *Hermann on Samarskite and the compounds of the Columbium metals* (ib., p. 463).—Hermann here reviews the composition of different minerals containing the metals of the columbium group. He deduces for Columbite the formula $\dot{\rm R}\ \bar{\rm R}$, the second metal including the Columbium and related metals; for Samarskite and Æschynite, $\dot{\rm R}\ \bar{\rm R}$; for Tantalite $\dot{\rm R}^2\ \bar{\rm R}^5$. He makes the oxyds of the Columbium metals, $\bar{\rm R}$, $\rm R$, $\bar{\rm R}$, $\dot{\rm R}$.

14. *Minerals of Elba.*—Mr. Antonio d'Achiardi of Pisa, has described the crystals of several of the minerals of Elba, in an article published in the Nuovo Cimento, II, iii, Feb., 1870. The species included are Quartz, Wollastonite, Beryl, Epidote, Lepidolite, Tourmaline, Ilvaite, and Orthoclase. He also publishes the analysis of a Halloysite—which afforded

$\ddot{\rm Si}$ 55·15, $\bar{\dddot{\rm A}}$l 27·72, $\dot{\rm Mg}$ and $\dot{\rm Ca}$ 5·10, $\dot{\rm K}$ 1·15, $\dot{\rm H}$ 10·20=99·32.

It is soapy in aspect and feel; milk-white, with small black and pale flesh-red spots; opaque, but becoming translucent in water; and adheres to the tongue.

15. *Mineralogische Notizen, of* F. Hessenberg.—The ninth number of Hessenberg's admirable crystallographic memoirs on minerals has recently been published by the Senckenberg Nat. Gesellschaft in Frankfort on the Maine (vol. vii, p. 257, 1870). It contains figures and measurements, with various observations, on the species Calcite from Lake Superior, Reissite of v. Fritsch, a rhombic Zeolite (perhaps a new mineral) from Santorin, Wollastonite, Periclin, Strontianite, Sphene, Caledonite, Hematite, Pyrite.

16. *Pencatite and Predazzite.*—The mineral carbonates Pencatite and Predazzite, which have been suspected to be only mixtures (see Dana's Min., 5th ed., 1868, p. 708) are proved to be such by G. Hauenschild, through a microscopic examination of specimens. He found them to be calcite, containing crystals of brucite.—*Sitzber. Ak. Wien.*, vol. lx, 1869.

17. *Rammelsberg on some native Tantalum and Columbium Compounds.*—In the *Zeitschrift* of the German Geological Society for 1869, at p. 586, Rammelsberg has a paper discussing the minerals *Tantalite, Yttrotantalite, Euxenite, Æschynite* and *Pyrochlore.*

In a paper commencing at page 106 of the same volume, Rammelsberg treats of the composition of *Silicates.*

18. *An Elementary Treatise on Quartz and Opal, including their varieties, with a notice of the principal foreign and British localities in which they occur;* by GEORGE WILLIAM TRAILL. New edition, greatly enlarged. 74 pp. 12mo. Edinburgh, 1870.—This beautifully printed little mineralogical volume contains descriptions of the many varieties of quartz and opal, with observations on their uses, localities, and other points of popular interest connected with them. The value of the work would be increased in another edition, by adding some account of the optical peculiarities of the species, about which there are many strange facts that might easily be made intelligible to minds little familiar with science.

III. BOTANY AND ZOOLOGY.

1. *How Crops Feed; a Treatise on the Atmosphere and the Soil as related to the nutrition of Agricultural Plants, with illustrations;* by SAMUEL W. JOHNSON, M.A., Prof. Analytical and Agricultural Chemistry in the Sheffield Scientific School of Yale College, &c. pp. 375, 18mo. New York: (Orange Judd & Co.) 1870. —This is the sequel to the treatise entitled "How Crops Grow," which was issued two years ago, and which has taken its place as an essential text-book. It was most promptly reproduced in England, very handsomely as respects the typography, &c., under the editorship of two Professors at the Royal Agricultural College at Cirencester,—by whom "numerous additions have been made to it, and in some parts it has been entirely rewritten." No means are furnished (at least we can find none) by which the reader can ascertain what the alterations and additions to this English edition are,—which seems unjust.

In the present volume, in considering "how crops feed," Prof. Johnson is in fullest force, upon ground that he has complete mastery of; and consequently he has produced a compendium of what is known of the chemistry and physics of vegetation which is eminently clear and satisfactory, and which supplies a long felt want. The first division of the book is devoted to the atmosphere, the second to the soil as related to vegetation; and the action of the various elements of each upon plants, especially the staple plants of agriculture, and of plants upon them, is in turn considered, with unusual perspicuity, and with about the fullness requisite for a text-book. From the biological side we might have wished to present some things somewhat differently,—to draw, for instance, a more marked line of distinction between vegetation as made up of organisms which, no less than animals, do work at the expense of organic materials and therefore produce or compose carbonic acid, and, on the other hand, as fulfilling the peculiar and essential work of vegetation, viz., the production of organic matter and the consequent decomposition of carbonic acid; and to distinguish also more definitely between this great operation which produces the materials for growth, and growth itself, which is the conversion of these into tissue or structure, and which of course goes on indifferently to light, which is all-essential to the former. The scientific reader will notice one of the author's strong and peculiar points, which is presented by way of conclusion in the final paragraph, viz., how several causes conspire to render the soil in a certain degree the conservator of its own fertility, by protecting its own resources from waste and too rapid use. A. G.

2. *Martius, Flora Brasiliensis*, fasc. 48: *Convolvulaceæ* expos. C. F. MEISSNER. Aug. 1869.—Prof. Meissner, who was obliged for a time to lay aside serious botanical work, here signalizes his return to it by a discriminating elaboration of the Brazilian *Convolvulaceæ*. The great genus *Ipomœa* is preserved in the extended sense, including *Calonyction*, *Quamoclit*, *Exogonium*, *Pharbitis*, &c., but with *Operculina* of Manso maintained as a genus. The work is extensively illustrated by 53 folio plates. A. G.

3. *Development of the Flower of Pinguicula vulgaris, &c.;* by Prof. A. DICKSON of the University of Glasgow. A quarto memoir, from the Trans. Roy. Soc. Edinb. 1869.—The letter-press and three excellent plates illustrate the organogeny of the flower of *Pinguicula*, and make out that the ovary is probably composed of five carpels,—certainly not of two, notwithstanding the bilabiate stigma,—and the placenta from the first free-central, so that the order should be regarded as Primulaceous in type, and not particularly related to *Scrophularineæ;* and then the embryos of this genus and of *Utricularia* are investigated and figured; the fact of the single cotyledon in *P. vulgaris* is confirmed, as well as of the two in other species, and the undivided or rather undeveloped and so-called acotyledonous embryo in *Utricularia vulgaris*. A. G.

4. *A Geographical Handbook of all the known Ferns, with Tables to show their Distribution;* by K. M. LYELL. London, Murray, 1870, pp. 225, 8vo.—Fern-amateurs are not very uncommon in this country; in England they abound; and to know ferns, if not to collect or cultivate them, is among educated people, especially ladies, rather the rule than the exception; and of popular Fern-books there is no small choice. Among them all we shall hardly meet with so solid and faithful a volume as this by Mrs. Col. Lyell. It is not a descriptive work, but, as its title denotes, is a full catalogue of the Ferns known in every particular country, with the ranges in each; followed by a series of compact and admirable tables, in which the genera and species are systematically arranged, and the distribution through all the continents or regions, and their main divisions, clearly indicated. Of course the main sources of information are the works of Sir William Hooker, and particularly the *Synopsis Filicum*, brought out by Mr. Baker, to which may be added the latter's elaborate memoir on the distribution of Ferns, in the Transactions of the Linnæan Society. Yet this volume must have cost long labor, and the result is well worth it. A. G.

5. *Bulletin of the Torrey Botanical Club.*—These 8vo sheets (of which we have Nos. 1 and 2, for January and February) are issued by the Club, which holds its regular meetings in the Tor-

reyan Herbarium at Columbia College, and has special oversight of the botany of the region immediately around New York. Some of its brief articles are of more than local interest. For instance, Dr. Allen, in the first number, shows that the dwarf *Œnothera* of Montauk Point, Long Island, is not *Œ. linearis*, as has been thought, but a depressed form of *Œ. fruticosa*, dwarfed, no doubt by the bleak exposure; and Mr. Leggett, the editor, announces the discovery, by Mr. Brown, of flowers fertilized in the closed bud in *Aristolochia serpentaria*. In the second number, Mr. Leggett explains how it came to pass that *Lepidium Virginicum*, unlike all its congeners, has accumbent cotyledons, and proves that it is by no means so different as has always been supposed. Also that the embryo in this species and its near allies partakes of the character which has been deemed peculiar to *Subularia*, *Senebiera*, &c., viz., in the fold being above the base of the cotyledons, not at their junction with the radicle. Mr. Leggett writes that, "In the species which I have examined, viz., the present, *L. ruderale*, *L. campestre*, and, perhaps, *L. intermedium*, the cotyledons are continued, in the form of petioles, about half way down the radicle; the cotyledons, in fact, being transversely folded upon themselves, as stated and illustrated in Gray's Genera in the case of *Subularia* and *Senebiera*, the genera immediately preceding *Lepidium*. In the other species of *Lepidium* the plane of division between these petioles, or 'radicular' portions of the cotyledons, is parallel to the cotyledons proper, and consequently to the seed partition. In *L. Virginicum* this split is likewise parallel to the partition, and thus the 'radicular' portions of the cotyledons, is incumbent, and so far the species is in accordance with its congeners. Where the cotyledons expand into a blade, they are turned sharply at right angles to the partition and become accumbent. If the embryo be held with the edge of the cotyledons toward the eye, it is the left blade which comes from the back of the radicle, and thus has the longer turn to make. *Cakile Americana*, Nutt., resembles *Lepidium Virginicum* in these particulars, except that the 'radicular' portion of the cotyledons is relatively much shorter, and in one instance I found the blades of the cotyledons almost spirally bent over the radicle, so as to pass, as it were, through an incumbent stage. I have also observed this narrowing of the cotyledons into a petiolar portion, greater or less, in *Nasturtium*, *Cardamine*, *Arabis*, *Barbarea*, *Erysimum*, and *Raphanus*, so far as represented in our local Flora; but in all those genera, the 'radicular' split has conformed nearly or quite to the cotyledons, as they are incumbent or accumbent: in *Cardamine* it is long and somewhat inclined to one side." We have verified this statement as respects *Lepidium Virginicum*, and only wonder how this conformation has been overlooked. No. 3, for March, has also been received. A. G.

6. *Notes relating to Vegetable Physiology, &c.*—A part of the following memoranda are drawn from the last numbers of the *Bulletin* of the Botanical Society of France, especially its *Revue Biographique*, which is very faithfully edited.

The effect of Barberry-bushes in rusting Wheat, after having long been accounted a groundless popular superstition, is at length understood and admitted by the Cryptogamists. The botanists used to rebut the charges of the farmers by the statement that the rust in the grain fields and the prevalent fungus of the Barberry belonged to very different genera, and that therefore the one could not give origin to the other. But DeBary in Germany and Œrsted in Denmark, following up similar enquiries by Tulasne in France, have concluded that *Uredo*, *Puccinia*, and *Œcidium* are to be regarded, not as so many genera, but as three successive forms of fructification of the same fungus, or in some sort an alternation of generations. DeBary ascertained that the spores of the *Puccinia graminis* do not germinate when sprinkled on the leaves and stalks of the cereal grains, which this rust infests, while they will germinate on the leaves of the Barberry, and there give rise to the *Æcidium Berberidis:* and the spores of this are equally inert upon the Barberry, but will grow in their turn upon Wheat, and there reproduce first the *Uredo* or yellow rust and later the *Puccinia graminis* or dark rust. Another species of *Puccinia* equally produces its corresponding *Æcidium* upon Buckthorn; another alternates between the cereal grains and certain Boragineous weeds. These results have been practically tested, in the large way, last summer, in France. Long hedges of Barberry, planted along the Paris and Lyons railway in a commune in the Côte d'Or, were complained of by the adjacent cultivators, and were cut away at certain places by way of experiment; and an investigation by the railroad company, whose interests were adverse to such a decision, left no doubt of the injurious effects of the Barberry on the contiguous wheat fields.

The turning green of etiolated plants, or in other words the production of chlorophyll upon exposure to light, was found by Guillemin to take place much more promptly under diffuse light than in direct sunshine. Sachs, finding that the blanched plantlets of Maize, which he used, turned green more rapidly when shielded by a paper cover than when exposed to the sun directly, attributed the result to the greater elevation of the temperature of the confined air. But Famintzin showed that the shaded plantlets turned green first at a lower temperature than those unshaded. Prillieux, from whose paper, read last autumn before the Botanical Society of France, these facts are taken, confirmed this result in two other ways,—first, by submitting the etiolated plantlets to different intensities of the same light from which the calorific rays had been mainly screened out, and secondly by placing them in a cone of light at different distances from the focus of the condensing lens; those in the brightest light remained apparently unchanged in color during an exposure which had sufficed to develop a decided green hue in those of feebler light. Prillieux thinks the difference is wholly physiological; that chlorophyll is formed promptly under light of a certain proper intensity, and not beyond; that it is slightly if at all produced under that stronger or direct light which acting upon this same chlorophyll is so efficient in the decomposition of carbonic acid and the consequent evolution of oxygen gas.

Boussingault, in one of the latest of his admirable papers on the functions of leaves, published in the Ann. Sci. Nat., tom. 10 of the current series, comes to the conclusion that, though leaves destitute of chlorophyll do not decompose any carbonic acid, yet that they begin to do so as soon as any chlorophyll is produced.

Is light absolutely requisite to the decomposition of carbonic acid in green foliage, and how much is necessary?—These questions are satisfactorily answered by Boussingault, through a series of experiments in which green leaves were introduced into a mixture of carbonic acid and hydrogen, over mercury, and the evolution of oxygen tested by the introduction of phosphorus, and its phosphorescence in the dark, or by the white cloud in light. He thus found, 1, that leaves do not decompose any carbonic acid in the dark, nor in twilight after sunset; but they do so very well under the diffuse light of a northern exposure, and under ordinary shade; as is shown indeed by the vegetation which thrives in the shade of a forest and the like; 2, that this evolution of oxygen begins as soon as the leaves are exposed to the light, and stops instantly when taken out of the light. Van Tieghem, experimenting upon aquatic plants, at first supposed he had proved the contrary, but in further experiments came to the same result.

To what portion of the solar radiation is this decomposition owing?—Prillieux, using light of different colors but of equal intensity, through colored solutions, thought he had ascertained that the decomposition was directly due to the luminous intensity, irrespective of the nature of the rays; that the orange and yellow rays and those of that part of the spectrum are most efficient merely because they are most luminous. But Dehérain, repeating these experiments, and measuring carefully the quantities of gas emitted, concludes that the blue and violet rays are not so effective as the yellow and red, when both are brought to the same intensity. Also that the same holds true of the evaporation of water from foliage. According to Dehérain, this is a transpiration rather than a simple evaporation, and is governed by the amount of light, and even goes on in a saturated atmosphere. He confirms an old observation of Guettard, that the water is more largely exhaled from the firmer and denser upper surface of the leaf,—which would not have been expected.

The movement of Protoplasm and of Chlorophyll with it, in the cells of leaves, on the other hand, is effected only by the rays of the other end of the solar spectrum, viz., the blue and violet. This is shown by Borodine (Acad. St. Petersb.), who has seen remarkable movements of the chlorophyll-grains in terrestrial plants, especially in the leaves of *Mnium*, a Moss, confirming an earlier discovery of Famintzin. In diffused light the grains of chlorophyll are applied to the surfaces of the cells parallel to the surface of the leaf or other organ: under direct light they promptly move away to the side walls, to return again when the light is diminished. This should be considered in connection with the observations, recorded above, that blanched plants do not turn green so readily under direct as under diffused light. Rose, more recently, concludes, as did Mohl long ago, that these movements do not originate in the grains of chlorophyll, but belong to the protoplasm in which they are imbedded.

Leaves illuminated by artificial light also decompose carbonic acid, as Prillieux shows, experimenting by electrical, the Drummond, and even common gas light.

Vegetation may thrive in an atmosphere rich in carbonic acid. This has been proved long ago as to an air containing ten per cent of this gas. Herié-Mangon, as stated by Dumas, caused a plant of *Thuja nana* to grow and prosper in an atmosphere half of which was carbonic acid.—That foliage takes in carbonic acid freely from the surrounding atmosphere, and also from water in the case of submerged plants, is well established.

Is carbonic acid taken in by the roots also? It was commonly thought that the greater part of this element of the plant's food was appropriated by the roots, either as dissolved in water or directly in the æriform state; and it is difficult to think otherwise when we consider the great store contained in every fertile or artificially manured soil, within reach of the roots of plants, and that the air in the pores of such a soil is vastly richer in carbonic acid than the atmosphere above. Nevertheless Corewinder of Lille thinks he has made out that it is not absorbed by the roots, at least in any considerably quantity, but only becomes available as it rises into the air and reaches the foliage. So unlikely a conclusion needs more decisive proof; although the favorable action of carbonic acid in respect to the solution of the mineral matters needed by the plant and absorbed by it, may be in some sort independent of its own absorption.

Oxalic acid, and especially Oxalate of Lime in plants, according to Arno Aë (in Ratisbon Flora) ought not to be regarded as in any proper sense products of excretion. They must play some essential part; for the leaves of perennials which contain oxalate of lime give it up in autumn before they perish to the parts which live over the winter, and it passes again in spring into the new vernal foliage.

Nature and use of the Latex. Schultz-Schultzenstein, with whom our principal knowledge of the vessels of the latex began, regarded the liquid they contain (the milky juice, &c., of certain plants) as truly representing the blood of animals, and therefore as nourishing fluid. Treviranus led off in the opposite opinion, which, drawing its strongest arguments from the fact that colored juices are found only in a comparatively small number of plants, and that they largely contain gum-resins and the like, pronounces this liquid to be a secretion and not a nourishing sap: this view was vigorously maintained by Von Mohl. Trécul, who has in these last dozen years done so much excellent work in vegetable anatomy, and especially upon the latex-vessels,—and who discovered their inosculation with or termination in ducts of all sorts and other elongated cells, and the penetration of the colored juices into these,—regards these juices as a kind of analogue of venous blood, which, having done its work in the cells, is conveyed into the ducts and thence to the leaves for a new elaboration. The recent German physiologists, Hanstein and Sachs, considering that latex is rich in assimilated matters, especially proteine, fit for nourishment, conclude that a part of it at least is employed in growth, and is therefore elaborated sap, although the caoutchouc, &c., in it may be excrementitious. In France, Faivre, who has formerly investigated the latex of *Ficus elastica*, has lately and for five years studied that of the White Mulberry. He confirms the last mentioned view; and shows that the latex of this tree contains a large proportion of assimilable nourishing matter, both ternary and quaternary, and that this matter is actually used by the plant in growth, in the way of an elaborated sap.

Insect-aid to Fertilization in plants, and the arrangements therefor, have been much studied of late by Hildebrand in Germany and Delpino in Italy. The former a few years ago wrote a systematic treatise on the subject which should be translated into English. In a later paper he has been noticing the successive disappearance from the tropics northward of certain tribes or groups of plants with the disappearance of the tribes of insects, or of humming birds, &c., which effect their fertilization: Roses, Peonies, &c., disappearing with the larger Coleoptera, many Silenes and Lychnises with nocturnal Lepidoptera, until, in the arctic zone there are only such flowering plants as are fertilized by the aid of Hymenoptera, Diptera, and the wind. Delpino, in analyzing the Phænogamous flora of Nova Zembla, concludes that of its 124 flowering plants, 16 are dichogamous by the aid of Hymenoptera, 84, dichogamous and monogamous by aid of these and Diptera, and 24 are fertilized by the wind. So of the 91 species in Spitzbergen, 2 are fertilized by Hymenoptera, 63 by Hymenoptera and Diptera, and 26 by the wind.

Fertilization in Acrogenous Cryptogamous plants. A valuable contribution has been made, by Strasburger, Professor in the University of Warsaw. His papers on the fertilization of Ferns, &c., are published in the Memoirs of the Imperial Academy of St. Petersburgh and the Bot. Zeitung for 1868, and are reproduced in French in the Ann. Sci. Naturelles. The interesting point is, that a mucilage, secreted in the canal of the archegonium or pistillidium and discharged from its orifice, serves to catch and entangle the moving spermatozoids and to direct their course down to the cell to be fertilized,—into which one or more of the spermatozoids work their way by their pointed end, while the other and enlarged globular extremity often breaks off and is left behind.

The influence of stock upon scion and the converse, which has of late been much under consideration, appears to be well made out in one kind of case, viz., in the propagation from the one to the other of variegation. The older facts of the sort are confirmed by some recent cases which Dr. Masters has exhibited to the Scientific Committee of the Royal Horticultural Society;—in which the foliage of the grafts of one species *Abutilon* took on variegation from the variegated stock of a different species; and *vice versa*, a variegated graft, inserted upon a green stock, and after a time pinched back, caused buds of the stock to develop with variegated foliage. Moreover, in a case recorded by Prof. Morren, the variegation ceased after the accidental destruction of the variegated graft; and it is said that "the mere insertion of a detached variegated leaf into a slit in the back of a green *Abutilon* was sufficient to inoculate the latter, even although the inserted leaf speedily perished." *Gard. Chronicle*, March 5.—Cases of this kind, which may best be regarded as the propagation of disease, bear however only indirectly upon the question of the sharing of special qualities between stock and scion. A. G.

7. Prof. FRANCIS UNGER, of Vienna, distinguished in Fossil Botany, &c., in former years the associate of Endlicher, died, in his native town of Gratz, February 12th, in the 69th year of his age. It was at first reported that he had died suddenly; then, that he was found "murdered in his bed." A. G.

8. *On Deep Sea Dredging in the neighborhood of the British Isles in* 1869:—*The Temperature, Currents, Life, Waters, and Gases present in the waters, in the depths of the Oceans;* by Dr. W. B. CARPENTER.—The following are extracts from a Lecture by Dr. Carpenter before the Royal Institution of Great Britain on the 11th of February last. We omit the most of what relates to the life of the sea bottom, as this part of the subject was presented by Prof. Verrill in our January number, at page 129. The discourse commences by giving the results of the three cruises of the Porcupine—undertaken to complete and extend the investigations made by the "Lightning" Expedition of 1868. The *first* cruise commenced from Galway, and was directed first to the southwest, then to the west, and finally to the northwest as far as the Rockall Bank; the greatest depth of dredging done by it was 1476 fathoms; the *second*, to the northern extremity of the Bay of Biscay, where a depth 2500 fathoms was known to exist, and dredging was carried to a depth of 2345 fathoms; the *third*, over the area between the north of Scotland and the Faroe Islands.

* * * The following summary of the results [with regard to *temperature*] brings into marked contrast the conditions of the warm and cold areas, which occupy respectively the W. S. W. and E. N. E. portions of the channel between the north of Scotland and the Faroe Islands, and lie side by side in its midst.

The *surface*-temperature may be said to be everywhere nearly the same, viz., 52°; the variations above or below this being attributable either to atmospheric differences (as wind, sunshine, &c.) or to difference of latitude. Alike in the warm and the cold areas there was a fall of from 3° to 4° in the first 50 fathoms, bringing down the temperature at that depth to 48°. A slow descent took place nearly at the same rate in both areas through the next 150 fathoms; the temperature in the warm area at the depth of 200 fathoms being 47°, whilst in the cold it was 45·7°. It is below this depth that the marked difference shows itself. For whilst in the warm area there is a slow and pretty uniform descent in the next 400 fathoms, amounting to less than *four degrees* in the whole, there is in the cold area a descent of *fifteen degrees* in the next 100 fathoms, bringing down the temperature at 300 fathoms to 30·8°. Even this is not the lowest; for the serial soundings taken at depths intermediate between 300 and 640 fathoms (the latter being the greatest depth met with in the cold area, midway between the Faroe and the Shetland Islands) showed a further progressive descent; the lowest bottom-temperature met with being 29·6°. Thus, while the temperature of the superficial stratum of the water occupying the cold area clearly indicates its derivation from the same source as the general body of water occupying the warm area, the temperature of the deeper stratum, which may have a thickness of more than *two thousand* feet, ranges from the freezing-point of fresh water to 2½° below it. Between the two is a *stratum of intermixture* of about 100 fathoms thickness, which marks the transition between the warm superficial layer and the body of frigid water which occupies the deeper part of the channel.

The shortest distance, within which these two contrasted submarine climates were observed at corresponding depths, was about 20 miles; but a much smaller distance was sufficient to produce it when the depth rapidly changed. Thus near the southern border of the deep channel, at a depth of 190 fathoms, the bottom-temperature was 48·7°; while *only six miles* off, where the depth had increased to 445 fathoms, the bottom-temperature was 30°·1. In the first case, the bottom evidently lay in the warm superficial stratum; whilst in the second it was overflowed by the deeper frigid stream.

It seems impossible to account for these phenomena on any other hypothesis than that of the *direct derivation of this frigid water from the Arctic basin.* And this agrees very well with other facts observed in the course of the exploration. Thus:—(1) The rapid descent of temperature marking the "stratum of intermixture" began about 50 fathoms nearer the surface in the most northerly portion of the cold area examined, than it did in the most southerly, as might be expected from the nearer proximity of the cold stream to its source. (2) The sand covering the bottom contains particles of volcanic minerals, probably brought down from Jan Mayen or Spitzbergen. (3) The fauna of the cold area has a decidedly Boreal type; many of the animals which abound in it having been hitherto found only on the shores of Greenland, Iceland, or Spitzbergen.

Although the temperatures obtained in the warm area do not afford the same striking evidence of the derivation of its whole body of water from a southern source, yet a careful examination of its condition seems fully to justify such an inference. For the water at 400 fathoms in lat. 59½° was only 2·4° colder than water at the same depth at the northern border of the Bay of Biscay, in a latitude more than 10° to the south, where the surface-temperature was 62·7°; and the approximation of the two temperatures is yet nearer at still greater depths, the bottom-temperature at 767 fathoms at the former station being 41·4°, whilst the temperature at 750 fathoms at the latter point was 42·5°. Now, as it may be certainly affirmed that the lowest temperature observed in the warm area is considerably above the isotherm of its latitude, and that this elevation could not be maintained against the cooling influence of the Arctic stream but for a continual supply of heat from a warmer region, the inference seems inevitable that the bulk of the water in the warm area must have come thither from the southwest. The influence of the Gulf Stream proper (meaning by this the body of superheated water which issues through the 'Narrows' from the Gulf of Mexico), if it reaches this locality at all—which is very doubtful—could only affect the *most superficial* stratum; and the same may be said of the surface-drift caused by the prevalence of southwesterly winds, to which some have attributed the phenomena usually accounted for by the extension of the Gulf Stream to these regions. And the presence of the body of water which lies between 100 and 600 fathoms' depth, and the range of whose temperature is from 48° to 42°, can scarcely be accounted for on any other hypothesis than that of a *great general movement of Equatorial water toward the Polar area*; of which movement the Gulf Stream constitutes a peculiar case modified by local conditions. In like manner, the Arctic Stream, which underlies the warm superficial stratum in our cold area, constitutes a peculiar case, modified by the local conditions to be presently explained, of *a great general movement of Polar water toward the Equatorial area*, which depresses the temperature of the deepest parts of the great Oceanic basins nearly to the freezing-point.

During the *first* and *second* cruises of the 'Porcupine,' the temperature of the eastern border of the great North Atlantic basin was examined at various depths between from 54 to 2435 fathoms, and in widely different localities, ranging from lat. 47° to lat. 55°. The *bottom*-temperature was ascertained at thirty stations, and *serial* soundings were taken at seven stations; making the total number of observations eighty-four. Amongst all these the coincidence of temperature at corresponding depths is extraordinarily close; the chief differences showing themselves in the temperature of the *surface* and of the stratum immediately beneath it. A decided *super-heating* is observable in this superficial stratum, not extending to a depth of much more than 70 or 80 fathoms, and more considerable at the southern than at the northern stations. Whether this 'super-heating' is entirely due to the direct influence of solar heat, or depends in any degree on an extension of the Gulf Stream as far as the southern part of the area examined, is a question which can only be resolved by the determination of its relative amount at different seasons. Between 100 and 500 fathoms, the rate of decrement is very slow, averaging only about 3° in the whole, or three-fourths of a degree for every 100 fathoms; and this body of water has a temperature so much above the isotherm of the northern stations, at which the observations were made, as decidedly to indicate that it must have found its way thither from a southern source. Between 500 and 750 fathoms, however, the rate of decrease becomes much more rapid, the reduction being 5°·4, or above 2° per 100 fathoms; while between 750 and 1000 fathoms it amounts to 3°·1, bringing down the temperature at the latter depth to an average of 38°·6. Beneath this there is still a slow progressive reduction with increase of depth, the temperature falling a little more than 2° between 1000 and 2435 fathoms; so that at the last-named depth, the greatest at which it was ascertained, it was 36°·5.—Thus it is obvious either that the vast body of water occupying the deeper half of the Atlantic basin has been itself derived from a colder region, or that its temperature has been reduced by the diffusion through it of frigid water from a Polar source. The latter supposition best accords with the *gradual* depression of temperature exhibited between 500 and 1000 fathoms which corresponds with the "stratum of intermixture" of the cold area.

The temperature-soundings recently taken by Commander Chimmo, R. N., and Lieutenant Johnson, R. N., at various points in the North Atlantic basin, when the requisite corrections are applied for the influence of pressure on the bulbs of the unprotected thermometers employed by them, give results which are remarkably accordant with our own; so that it may be stated with confidence that the temperature of the deeper parts of the North Atlantic sea-bed is but a very few degrees above the freezing-point.

Now a glance at the North Polar region, as laid down either on a globe, or any projection of which the Pole is the center, shows that the Polar basin is so much shut in by the northern shores of the European, Asiatic, and American continents, that its only communication with the North Atlantic basin—besides the circuitous passages leading into Hudson's and Baffin's Bays—is the space which intervenes between the eastern coast of Greenland and the northwestern portion of the Scandinavian peninsula. If, therefore, there be any such general interchange of polar and equatorial water as that for which we have argued, the Arctic current must flow through the deeper portions of this interspace, at the north of which lies Spitzbergen, whilst Iceland and the Faroes lie in the middle of its southerly expanse. Now in the channel that lies between Greenland and Iceland, the depth is such as to give a free passage to such a frigid stream; but between Iceland and the Faroe Islands there is no depth so great as 300 fathoms at any part, except in a narrow channel at the southeast corner of Iceland; so that an effectual barrier is thus interposed to any movement of frigid water at a depth exceeding this. A similar barrier is presented, not merely by the plateau on which the British Islands rest, but also by the bed of the North sea; the shallowness of which must give to such a movement a not less effectual check than would be afforded by an actual coast-line uniting the Shetland Islands and Norway. Consequently, it is obvious that a flow of ice-cold water at a depth exceeding 300 fathoms from the surface, down the northeastern portion of this interspace, *can* only find its way southward through the deeper portion of the channel between the Faroe and Shetland Islands; which will turn it into a W. S. W. direction between the Faroe Islands and the north of Scotland, and finally discharge such part of it as has not been neutralized by the opposing stream coming up from the southwest, into the great North Atlantic basin, where it will meet the Icelandic and Greenland currents, and unite with them in diffusing frigid waters through its deeper portion. In thus spreading itself, however, the frigid water will necessarily mingle with the mass of warmer water with which it meets, and will thus have its own temperature raised, whilst lowering the general temperature of that mass; and hence it is that we do not find the temperature of even the greatest depths of the Atlantic basin nearly so low as that of the comparatively shallow channel which feeds it with Arctic water.

It may be questioned, however, whether the whole body of Arctic water that finds its way through the channels just indicated, could alone maintain so considerable a reduction in the temperature of the enormous mass which lies below 1000 fathoms in the Atlantic basin; subject as this must be to continual elevation by the surface-action of the sun on its southern portion. And as the few reliable observations on Deep-sea Temperatures under the equator indicate that even there a temperature not much above 32° prevails, it seems probable that part of the cooling effect is due to the extension of a flow of frigid water from the Antarctic Pole, even north of the Tropic of Cancer. Of such an extension there is evidence in the temperature-soundings recently taken in H.M.S. 'Hydra' between Aden and Bombay, where the cooling influence could scarcely have been derived from any other source than the Antarctic area.*

The unrestricted communication which exists between the Antarctic area and the great Southern Ocean-basins would involve, if the doctrine of a general Oceanic circulation be admitted, a much more considerable interchange of waters between the Antarctic and Equatorial areas, than is possible in the Northern hemisphere. And of such a free interchange there seems adequate evidence; for it is well known to navigators that there is a perceptible 'set' of warm surface-water in all the southern oceans toward the Antarctic Pole; this 'set' being so decided in one part of the Southern Indian Ocean, as to be compared by Capt. Maury to the Gulf Stream of the North Atlantic.† Conversely, it would appear from

* The lowest temperature *actually observed* in these soundings was 36½°. The temperature of 33½° given in the previous discourse, as existing below 1800 fathoms, proves to have been only an *estimate* formed by Captain Shortland under the idea that the rate of reduction observed at smaller depths would continue uniform to the bottom, which the serial soundings of the 'Porcupine' prove to be by no means the case.

† 'Physical Geography of the Sea,' §§ 748–750.

the application of the necessary pressure-correction to the temperatures taken in Sir James Ross's Antarctic expedition, the voyage of the 'Venus,' &c., at depths greater than 1000 fathoms, that the bottom-temperature of the deepest parts of the Southern Oceanic basin really approaches the freezing-point, or is even below it. And if the temperature of the deeper portion of the *North* Pacific Ocean should be found to exhibit a depression at all corresponding to that of the North Atlantic, it must be attributed entirely to the extension of this Antarctic flow; since the depth of Behring's Strait, as well as its breadth, is so small as to permit no body of Arctic water to issue through that channel.† * * * *

The *Foraminifera* collected in the 'Porcupine' expedition present features of no less interest, though their scale is so much smaller. The enormous mass of Globigerina-mud (sometimes almost pure, sometimes mixed with sand) that everywhere covers the deep-sea bottom in the region explored, save where its temperature is reduced nearly to the freezing-point, may be judged of from the fact that in one instance the dredge brought up *half a ton* of it from a depth of 767 fathoms. The resemblance of this deposit to chalk is greatly strengthened by the recognition of several characteristically Cretaceous types among the Foraminifera scattered through the mass of *Globigerinæ* of which it is principally composed; as also that of *Xanthidia*, frequently preserved in flints. Not many absolute novelties presented themselves among the foraminifera that form true calcareous *shells;* the chief point of interest being the occurrence of certain types of high organization at great depths, and their attainment of a size that is only paralleled in much warmer latitudes, or in the Tertiary or yet older formations. This is especially the case with the *Cristellarian* group, which has a long geological range; and also with the *Miliolinæ*, of which specimens of unprecedented size presented themselves. The most interesting novelty was a beautiful *Orbitolite*, which, when complete, must have had the diameter of a sixpence, but which, from its extreme tenuity, always broke in the process of collection.—Of arenaceous Foraminifera, however, which construct *tests* by cementing together sand-grains, instead of producing shells, the number of new types is such as to seriously tax our power of inventing appropriate generic names. Many of these types have a remarkable resemblance to forms previously known in the Chalk, the nature of which had not been recognized. Some of them throw an important light on the structure of two gigantic arenaceous types from the Upper green-sand, recently described by the speaker and Mr. H. B. Brady, an account of which will appear in the forthcoming part of the 'Philosophical Transactions;'

† This statement is not in accordance with the observations hitherto made on the temperatures of the ocean along the Asiatic coast of the Pacific and the distribution of oceanic life; for these indicate a north Polar current as decided as that of the Atlantic. See the isothermal chart of the oceans in Dana's Report on Crustacea, and in this Journal, II, vol. xvi, 1853, and also his Manual of Geology. The observations on the animal life of the coast, made by W. Stimpson, in the Ringgold Expedition, are confirmatory evidence on this point.—J. D. D.

and there is one which can certainly be identified with a form lately discovered by Mr. H. B. Brady in a clay-bed of the Carboniferous limestone.

The question now arises, whether—as there must have been deep seas in all geological periods, and as the changes which modified the climate and depth of the sea-bottom were for the most part very gradual—we may not carry back the continuity of the accumulation of *Globigerina*-mud on some part or other of the ocean-bed into geological epochs still more remote; and whether it has not had the same large share in the production of the earlier calcareous deposits that it has undoubtedly had in that of the later. The Foraminiferal origin of certain beds of the Carboniferous limestone, for example, appears to be indicated by the presence of *Globigerinæ*, long since observed by Professor Phillips in sections of them, as well as by the fact just stated. The sub-crystalline character of these rocks cannot be regarded as in any way antagonistic to such an idea of their origin, since it is perfectly well known that all traces of the organic origin of calcareous rocks may be completely removed by subsequent metamorphism,—as in the Chalk of the Antrim coast.

What is the *source of nutriment* for the vast mass of animal life covering the abyssal sea-bed is a question of the greatest biological interest. That animals have no power in themselves of generating the organic compounds which serve as the materials of their bodies—and that the production of these materials from the carbonic acid, water, and ammonia of the Inorganic world, under the influence of light, is the special attribute of vegetation—is a doctrine so generally accepted, that to call it in question would be esteemed a physiological heresy. There is no difficulty in accounting for the alimentation of the higher animal types, with such an unlimited supply of food as is afforded by the *Globigerinæ* and the *Sponges* in the midst of which they live, and on which many of them are known to feed. Given the *Protozoa*, everything else is explicable. But the question returns,—On what do these *Protozoa* live?

The hypothesis has been advanced that the food of the abyssal *Protozoa* is derived from *Diatoms* and other forms of minute plants, which, ordinarily living at or near the surface, may, by subsiding to the depths, carry down to the animals of the sea-bed the supplies they require. Our examination of the surface-waters, however, has afforded no evidence of the existence of such microphytic vegetation in quantity at all sufficient to supply the vast demand; and the most careful search in the Globigerina-mud has failed to bring to light more than a very small number of specimens of these siliceous envelopes of Diatoms, which would most assuredly have revealed themselves in abundance, had these protophytes served as a principal component of the food of the *Protozoa* that have their dwelling-place on the sea-bed.—Another hypothesis has been suggested, that these *Protozoa*, which are so near the borders of the vegetable kingdom, may be able, like plants, to generate organic compounds for themselves—manufacturing their own food, so to speak, from inorganic materials. But it is scarcely conceivable that they should do this without the agency of light; and, as it is obviously the want of that agency which excludes the possibility of vegetation in the abysses of the ocean, the same deficiency would prevent animals from carrying on the like process.

A possible solution of this difficulty, offered by Prof. Wyville Thomson in a lecture delivered last spring, has received so remarkable a confirmation from the researches made in the 'Porcupine' expedition, that it may now be put forth with considerable confidence. It is, he remarked, the distinctive character of the *Protozoa*, that "they have no special organs of nutrition, but that they absorb water through the whole surface of their jelly-like bodies. Most of these animals secrete exquisitely-formed skeletons, sometimes of lime, sometimes of silica. There is no doubt that they extract both of these substances from the sea-water, although silica often exists there in quantity so small as to elude detection by chemical tests. All sea-water contains a certain amount of organic matter in solution. Its sources are obvious. All rivers contain a large quantity; every shore is surrounded by a fringe, which averages about a mile in width, of olive and red sea-weeds; in the middle of the Atlantic there is a marine meadow, the Sargasso Sea, extending over 3,000,000 of square miles; the sea is full of animals which are constantly dying and decaying; and the water of the Gulf Stream, especially, courses around coasts where the supply of organic matter is enormous. It is, therefore, quite intelligible that a world of animals should live in these dark abysses: but it is a necessary condition that they should chiefly belong to a class capable of being supported by absorption through the surface of matter in solution; developing but little heat, and incurring a very small amount of waste by any manifestation of vital activity. According to this view, it seems highly probable that at all periods of the earth's history some form of the Protozoa—Rhizopods, Sponges, or both—predominated over all other forms of animal life in the depths of the sea; whether spreading, compact, and reef-like, as in the Laurentian and Palæozoic *Eozoön*; or in the forms of myriads of separate organisms, as in the *Globigerinæ* and *Ventriculites* of the Chalk."*

During each cruise of the 'Porcupine,' samples of sea-water obtained from various depths, as well as from the surface, at stations far removed from land, were submitted to the permanganate test, after the method of Prof. W. A. Miller, with an addition suggested by Dr. Angus Smith for the purpose of distinguishing the organic matter *in a state of decomposition* from that which is only *decomposable*; with the result of showing the uniform presence of an appreciable quantity of matter of the latter kind, which, not having passed into a state of decomposition, may be *assimilable* as

* "The Depths of the Sea," a Lecture delivered in the theatre of the Royal Dublin Society, April 10, 1869.

food by animals,—being, in fact, protoplasm in a state of extreme dilution. And the careful analyses of larger quantities collected during the third cruise, which have been since made by Dr. Frankland, have fully confirmed these results, by demonstrating the *highly azotized* character of this organic matter, which presents itself in samples of sea-water taken up at from 500 to 750 fathoms depth, in such a proportion that its universal diffusion through the oceanic waters may be safely predicated.

Until, therefore, any other more probable hypothesis shall have been proposed, the sustenance of animal life on the ocean-bottom at any depth may be fairly accounted for on the supposition of Prof. Wyville Thomson, that the Protozoic portion of that fauna is nourished by the direct absorption from the dilute protoplasm diffused through the whole mass of oceanic waters, just as it draws from the same mass the mineral ingredients of the skeletons it forms. This diffused protoplasm, however, must be continually undergoing decomposition, and must be as continually renewed; and the source of that renewal must lie on the *surface-life* of plants and animals, by which (as pointed out by Prof. Wyville Thomson) fresh supplies of organic matter must be continually imparted to the oceanic waters, being carried down even to their greatest depths by that *liquid diffusion* which was so admirably investigated by the late Professor Graham.

Not only, however, has the nutrition of the abyssal fauna to be explained; its *respiration* also has to be accounted for; and on this process also the results of the analyses of the gases of the sea-water made during the 'Porcupine' expedition throw very important light. Samples were collected not only at the surface, under a great variety of circumstances, but also from great depths; and the gases expelled by boiling were subjected to analysis according to the method of Prof. W. A. Miller—the adaptation of his apparatus to the exigencies of ship-board having been successfully accomplished during the first cruise by Mr. W. L. Carpenter. The general average of thirty analyses of surface-water gives the following as the percentage proportions:—25·1 oxygen, 54·2 nitrogen, 20·7 carbonic acid. This proportion, however, was subject to great variations, as will presently be shown. As a general rule, the proportion of oxygen was found to diminish, and that of carbonic acid to increase, with the depth: the results of analyses of *intermediate* waters giving a percentage of 22·0 oxygen, 52·8 nitrogen, and 26·2 carbonic acid; while the results of analyses of *bottom*-waters gave 19·5 oxygen, 52·6 nitrogen, and 27·9 carbonic acid. But *bottom*-water at a comparatively small depth often contained as much carbonic acid and as little oxygen as *intermediate* water at much greater depths; and the proportion of carbonic acid to oxygen in *bottom*-water was found to bear a much closer relation to the abundance of animal life (especially of the more elevated types), as shown by the dredge, than to its depth. This was very strikingly shown in an instance in which analyses were made of the gases contained in samples of water collected at every 50 fathoms, from 400 fathoms to the bottom at 862 fathoms, the percentage results being as follows:

	750 fath.	800 fath.	Bottom, 862 fath.
Oxygen - -	18·8	17·8	17·2
Nitrogen - - -	49·3	48·5	34.5
Carbonic acid -	31·9	33·7	48·3

The extraordinarily augmented percentage of carbonic acid in the stratum of water here immediately overlying the sea-bed was accompanied by a great abundance of animal life. On the other hand, the lowest percentage of carbonic acid found in bottom-water —viz: 7·9—was accompanied by a "very bad haul." In several cases in which the depths were nearly the same, the analyst ventured a prediction as to the abundance, or otherwise, of animal life, from the proportion of carbonic acid in the bottom-water; and his prediction proved in every instance correct.

It would appear, therefore, that the increase in the proportion of carbonic acid, and the diminution in that of the oxygen, in the abyssal waters of the ocean, is due to the respiratory process, which is no less a necessary condition of the existence of animal life on the sea-bed, than is the presence of food-material for its sustenance. And it is further obvious that the continued consumption of oxygen and liberation of carbonic acid would soon render the stratum of water immediately above the bottom completely irrespirable—in the absence of any antagonistic process of vegetation—were it not for the upward diffusion of the carbonic acid through the intermediate waters *to the surface*, and the *downward* diffusion of oxygen *from* the surface to the depths below. A continual interchange will take place *at* the surface between the gases of the sea-water and those of the atmosphere; and thus the respiration of the abyssal fauna is provided for by a process of diffusion, which may have to operate through *three miles* or more of intervening water.

The varying proportions of carbonic acid and oxygen in the *surface*-waters are doubtless to be accounted for in part by the differences in the amount and character of the animal life existing beneath; but a comparison of the results of the analyses made during the agitation of the surface by wind, with those made in calm weather, showed so decided a reduction in the proportion of carbonic acid, with an increase in that of oxygen, under the former condition, as almost unequivocally to indicate that superficial disturbance of the sea by atmospheric movement is absolutely necessary for its purification from the noxious effects of animal decomposition. Of this view a most unexpected and remarkable confirmation has been afforded by the following circumstance:—In one of the analyses of surface-water made during the second cruise, the percentage of carbonic acid fell as low as 3·3, while that of oxygen rose as high as 37·1; and in a like analysis made during the third cruise, the percentage of carbonic acid was 5·6; while that of oxygen was 45·3. As the results of every other analysis of surface-water were in marked contrast to these, it became a question whether they should not be thrown out as erroneous;

until it was recollected that, while the samples of surface water had been generally taken up from the *bow* of the vessel, they had been drawn in these two instances from *abaft the paddles*, and had thus been subjected to such a violent agitation in contact with the atmosphere, as would preëminently favor their thorough aëration.

Hence, then, it may be affirmed that every disturbance of the ocean-surface by atmospheric movement, from the gentlest ripple to the most tremendous storm-wave, contributes, in proportion to its amount, to the maintenance of animal life in its abyssal depths —doing, in fact, for the aëration of the fluids of their inhabitants, just what is done by the heaving and falling of our own chests for the aëration of the blood which courses through our lungs. A perpetual calm would be as fatal to their continued existence, as the forcible stoppage of all respiratory movement would be to our own. And thus universal stagnation would become universal death. * * *

In conclusion, he referred to the systematic and energetic prosecution of deep-sea explorations by the United States Coast Survey and by the Swedish Government—the results of which appear to be singularly accordant with those now briefly expounded,—as showing that other maritime powers are strongly interested in the subject; and expressed the earnest hope that the liberal assistance of H. M. Government, which has already enabled British Naturalists to obtain the lead in this inquiry, would be so continued as to enable them to keep it in the future. In particular, he called attention to the suggestion lately thrown out by M. Alex. Agassiz, that an arrangement might be made by our own Admiralty with the Naval authorities of the United States; by which a thorough survey, physical and biological, of the North Atlantic should be divided between the two countries; so that British and American explorers, prosecuting in a spirit of generous rivalry labors most important to the science of the future, might meet and shake hands on the mid-ocean.

9. *Secretion of Sulphuric acid by certain Gasteropods.*—During the autumn of 1853, Professor TROSCHEL succeeded in obtaining in Messina two specimens of the gigantic gasteropod *Dolium galea* Lk., intending to remove the animal from its shell for preservation. One of the mollusks threw out its enormous proboscis to defend itself, and M. Troschel seized it for examination; when immediately there was projected from this proboscis a drop of a limpid liquid which, falling upon the marble pavement of the room, produced, much to his astonishment, an active effervescence. He succeeded in collecting a portion of this liquid, and in proving it to be a secretion of the salivary gland. A few months later, this saliva was analyzed by Dr. Bœdeker of Bonn, who found in it free sulphuric acid.

Shortly after, MM. Quoy and Gaimard, having discovered in the genus *Cassis*, a gland analogous to that of the *Dolium*, suggested that possibly these gasteropods also secreted a similar fluid, using it perhaps as a means of defense, but also to aid them in perforating bivalve shells. The *Dolium* saliva was subsequently analyzed by W. Preyer, and Keferstein published a description of the gland.

This was the state of the question when Professor Panceri—whose paper has just been published in the Memoirs of the Royal Academy of Naples—undertook its investigation. He associated Professor de Luca with him in the work, and to him we are indebted for new analyses of this remarkable secretion. These analyses were comparative, made upon the saliva of two similar individuals. The liquid was colorless, and slightly opaline from the presence of a sulpho-nitrogenous organic substance precipitable by alcohol. Its density was 1·025 in (I) and 1·030 in (II). The analysis gave:

	I.	II.
Free sulphuric acid,	3·42	3·30
Combined sulphuric acid,	0·20	0·15
Combined chlorhydric acid,	0·58	0·60
Potassa, soda, magnesia, oxyd of iron, phosphates, organic matter and loss,	1·80	2·35
Water,	94·00	93·60
	100·00	100·00

The mollusks, their shells, and their glands were separately weighed, with results as follows:—

	I.	II.
Mollusks,	1305 grams.	520 grams.
Shells,	550 "	255 "
Glands,	150 "	80 "
	2005 "	855 "

Hence the glands constitute from 7 to 9 per cent of the total weight of the animal.

Moreover, M. Panceri found that on laying open the secretory gland of a *Dolium*, there was evolved, within a few moments, a considerable quantity of gas, which, on examination, proved to be pure carbonic acid. One gland, weighing approximately 45 grams, yielded 206 cubic centimeters of this gas. As to the secretion of so acid a fluid from the alkaline blood of the mollusk, this cannot surprise us, since it is entirely analogous to the secretion of an acid gastric juice from a similarly alkaline blood in the higher animals.

The following list comprises those species of mollusks which, like the *Dolium galea*, secrete an acid saliva:—

Prosobranchs.	Opisthobranchs.
Cassis sulcosa Lk.	*Pleurobranchidium Meckelii* Leuc.
Tritonium nodiferum Lk.	*Pleurobranchus tuberculatus* Meck.
" *hirsutum* Fab. Col.	" *testitudinarius* Cantr.
" *cutaceum* (*cretaceum?*) Lk.	" *brevifrons* Phil.
" *corrugatum* Lk.	*Doris* ———
Cassidaria echinophora Lk.	

No trace of such a secretion has been detected in the genera Carinaria, Firola, Phylliroë or in any of the numerous perforating Acephala, such as the Pholas.

After describing minutely the anatomy of the secreting organ, in both the above divisions of gasteropods, M. Panceri closes his paper with some remarks upon the origin and function of this unique secretion. Has the sulphuric acid its origin in the oxydation of the sulphur of the albuminoid tissues, or does it result from a decomposition of the sulphates found in sea-water? M. Panceri is inclined to the latter hypothesis, since, as is well known, the circulatory system of the gasteropods is so arranged at the extremity of the body as to permit the water in which they live to enter the blood in small quantity. With regard to the *role* played by the acid in this secretion, M. Panceri considers it useful solely for defense; the habits of the gasteropods studied by him forbidding the hypothesis that it is used to perforate hard bodies. Two views may be taken of the decomposition which produced this acid: 1st, it may take place solely for the purpose of obtaining the acid, in which case the secretion and emission will be but secondary and intermittent; or 2d, its production may be regular and continuous, the sulphuric acid like urea for example, being an effete product resulting from the normal chemical changes taking place in the body.—*Les Mondes*, II, xxii, 451, March 10, 1870.

10. *On the discovery of the sensitiveness to light possessed by Unios;* by William Sharswood.—In the March number of this Journal for 1869, p. 280, Prof. C. A. White has published an article under the caption "Are Unios sensitive to light?" in which he has recited some experiments by which he had been led to justly believe "that no doubt is entertained that the posterior portion of this mollusk is keenly sensitive to light, but exactly what organs are thus sensitive has not been ascertained." In the May number of this Journal for 1869, another article on this subject is presented over the caption "*Are Unios sensitive to light?* by Isaac Lea," in which are brought out Dr. Lea's prior observations establishing the same fact; referring to the Proceedings of the Academy of Natural Sciences of Philadelphia, for 1857, to substantiate his claim, and to a subsequent publication in the Introduction to vol. vi of his "Observations on the Genus Unio." Now the fact is that Mr. Lea was anticipated, by fourteen or fifteen years, in a few lines, by Prof. S. S. Haldeman, in his "Fresh-water Univalve Mollusca," Physadæ, January, 1843, p. 8, where he says, "In the other fresh-water families described in this work, the power of vision, or sensitiveness to the action of light, is rendered evident by intercepting it with an opaque object, when they instantly retract; and I have even observed the protruded branchial canal of *Unio radiatus* (Gmelin) to be suddenly withdrawn, when subjected to the same experiment." The following is another statement on the subject by the same author, published in the Iconographic Encyclopedia, Zoology, p. 69. (New York, 1850). "The extremity [of

the siphons in Unio] scarcely extends beyond the shell; it is papillate, and provided with eyes which have the power of distinguishing light from darkness, as the siphons are suddenly withdrawn, when a shadow is cast upon them."

Philadelphia, 24th and Sharswood Sts., March 9, 1870.

11. *Report on the Invertebrata of Massachusetts*, published agreeably to an order of the Legislature. Second edition, comprising the Mollusca; by AUGUSTUS A. GOULD, M.D., edited by W. G. BINNEY. Boston, 1870.—Like most revisions of antiquated works, this is a somewhat unsatisfactory book. The difficulties have even been much greater than usual, in this instance, on account of the death of the author at a time when the revision of the original work was in a very unsatisfactory and unfinished condition, which necessarily made the task of the editor laborious and the resulting work quite different, probably, from what either the author or editor would have personally wished.

The typography and illustrations of the book are excellent and do credit both to the State and the editor, as well as to the artists. The wood-cuts, of which there are 405, have nearly all been drawn from nature by Mr. E. S. Morse, whose rare artistic talent and thorough knowledge of the subject have enabled him to produce figures that are unequaled in accuracy. The drawings have been most faithfully reproduced by the engraver, Mr. Henry Marsh, whose skill contributed so largely to the value of Harris' Report on Insects. The accuracy and beauty of the cuts makes us regret that a portion of the labor had not been expended upon the hinges and interior parts of the bivalves, lingual dentition and opercula of the Gasteropods, and other parts, which are of far greater importance than mere external views, no matter how accurate.

The twelve plates are, with one exception, printed in colors and illustrate well the Nudibranchs, Ascidians, Cephalopods and some of the Pteropods. The Bryozoa and all the Radiates and Articulates are omitted from this edition, which was undoubtedly the wisest course, for these groups, which were extremely imperfectly represented in the first edition, have now been so numerously collected and become so well known that at least another volume, the size of the present, would be required to do them any justice. The greatest improvement upon the text of the first edition is the part relating to the Nudibranchs, which was elaborated by Dr. Gould some time before his death. Several species not before described or noticed are introduced, and all the species are well described and illustrated with colored figures. The Ascidians, which were very briefly and imperfectly treated in the first edition, now occupy 27 pages, and include 29 nominal species. Dr. Gould had prepared nothing on this class and the editor has unfortunately been obliged to compile the descriptions, many of them very brief and almost worthless, in fact hardly meriting the name of descriptions, which have been published in various other works. The figures are, however, mostly very good. Some, which were drawn from life by Mr. Burkhardt, have been contributed by Prof. Agassiz, but others have been drawn from alcoholic specimens and give but a poor idea of the form and appearance of the animals when living. In consequence of compiling both bad descriptions and good ones, several species of Ascidians appear under two different names. Thus *Cynthia placenta* Packard is the same as *Ascidia carnea* Ag., and is a true *Cynthia*; *C. gutta* Stimpson is, perhaps, the young of the same species, which is abundant and of larger size in the Bay of Fundy. *Molgula arenata* Stimpson is the same, in all probability, as *Ascidia psammophora* Agassiz, but the figure of the latter is very poor and does not represent the normal state of expansion. This species is abundant on certain sandy bottoms near New Haven, and is a true *Molgula*. *Ascidia ocellata* Agassiz appears to be the same as *A. tenella* Stimpson. The figure of the latter agrees exactly with numerous specimens, which we obtained living abundantly from low-water to 50 fathoms at Eastport, Me., which are no doubt Stimpson's species. *Boltenia microcosmus* Agassiz is probably only a reddish variety of *B. clavata*; we have often observed such variations among the many hundreds of specimens of *B. clavata* collected at Eastport, Me., where it is very abundant from low-water to 50 fathoms. *Glandula mollis* Binney is not the species described by Stimpson under that name, even if it belongs to the genus *Glandula*, which is very doubtful; figure 328, at least, looks much more like a *Cynthia* or an *Ascidia*. Perhaps two species are confounded together, but neither can be *G. mollis*, which is an abundant species at Eastport and very constant in its characters, as described by Dr. Stimpson. Although the names given by Agassiz to some of the species above mentioned are earlier than Stimpson's, no descriptions were given by which the species could possibly be recognized, except perhaps in the case of *A. ocellata*, in which the ocellæ are so prominent a feature. Therefore the names given by Stimpson, and accompanied by good descriptions, should be retained. But there are quite a number of Ascidians, living on the New England coast, which have been entirely omitted. The part relating to Conchifera has been much improved and enlarged, and many additional species introduced. All the species are beautifully illustrated by external views, but no figures of the hinge or internal markings are given, except in very few instances. The parts relating to Pteropods and Cephalopods are mostly compiled from various sources by the editor. It is to be regretted that more attention was not bestowed upon the distribution of the species in depth and geographically, for a very large amount of information of this kind has accumulated since the first edition, but often only the old localities are mentioned, though Dr. Stimpson had given a far greater amount of information of this kind, as long ago as 1851, in his "Shells of New England," which has not even been incorporated into the present work.

Most conchologists and naturalists generally will be surprised at the extent to which obsolete ideas of classification are retained. Thus we find the Brachiopods introduced between the Conchifers and Gasteropods! The *Scalaridæ* between *Littorinidæ* and *Vermetidæ!* In fact the arrangement of the families is very often unnatural. We find, also, many singular inconsistencies in the genera adopted, for in some families the modern views and modern names are introduced to a considerable extent, while in others, where such changes were even more desirable, the old ideas and the old genera are retained from the first edition, almost without change. But by way of apology we find the following in the editor's preface: "Should any disappointment be felt that Dr. Gould has not adopted in his work all the improvements in classification, &c., which more recent investigations have suggested, it must be remembered that this is not a new work. It is rather a reprint of an old one, with such additions and improvements as Dr. Gould considered absolutely necessary to its present usefulness." Also, "upon assuming the charge of the publication and receiving the manuscripts, drawings, notes, &c. of Dr. Gould, I endeavored to learn thoroughly what plan he had made for revising the first edition, as I was directed to complete the work *as nearly as possible in accordance with the views and wishes of the author.* I believe I have been able to arrive at a clear idea of his intentions, which, according to my orders, I have most scrupulously endeavored to carry out, irrespective of my own opinions. It is only in treating the *Pulmonifera* that I have exercised my own judgment, and here only to the extent that I believe Dr. Gould would have approved." We do not exactly understand how it is that the editor did not also *exercise his own judgment* in treating the Ascidians, Pteropods, and Cephalopods, since he informs us that nothing had been prepared by Dr. Gould relating to these classes. But we fear the editor has in some cases done Dr. Gould injustice by not introducing important and essential changes, which he himself would undoubtedly have adopted, had he lived to completely revise the work. Thus there seems to be no reason why many genera, now well established, should not have been adopted. For example, *Eurosalpinx* established for "*Buccinum cinereum*," which has nothing to do with *Buccinum*; *Phychatractes* Stimpson for "*Fasciolaria ligata*," etc. Even among the *Pulmonifera*, where Mr. Binney is on his own familiar ground, there are many inconsistencies which we cannot suppose that Dr. Gould would have approved of, and which can scarcely be in accordance with the editor's own judgment. Thus we find the "*Helix? harpa*" Say still retained under Say's name, although Mr. Morse has well elucidated its anatomical and physiological peculiarities, showing it to be viviparous and to have many other characters entitling it *at least* to distinct *generic* rank, and has established the genus *Zoögenites* for it, which certainly has stronger claims than some other genera of the same family, which are adopted in this work; neither do we see sufficient reasons for retaining *Helix striatella*, *H. labyrinthica*, *H. asteriscus*, *H. pulchella*, etc. in the genus *Helix*, when *H. arborea*, *H. electrina*, *H. chersina*, *H. lineata*, etc. are separated as *Hyalina*. It would have appeared to us better to have retained *all* the species in the old "genus" *Helix*, than to have produced such an unphilosophical mixture of old and new ideas as we find in this case and others.

Finally we may remark that although this work will prove of but little or no use for conveying correct ideas of classification, or even of the character of genera, it will nevertheless be indispensable and of the utmost value in the determination of the species.

V.

12. *Notes on American Crustacea, No.* 1, *Ocypodoidea;* by SIDNEY I. SMITH. 8vo, 64 pages, with 4 lithographic plates. From the Transactions of the Connecticut Academy, Vol. II, April, 1870.—This memoir includes a nearly complete monograph of the American species of *Gelasimus* or "fiddler-crabs," of which 21 species are now known from both coasts of America. Of these 14 are described at length in this paper, including 9 that are new, and most of them are illustrated. In addition to these a number of new genera and species are described, and of others, previously known, more accurate and complete descriptions are given. One new family, *Dissodactylidæ*, allied somewhat to the *Pinnotheridæ*, but differing from that and all other families of Ocypodoidea in having a palate or endostome which is not divided by a median ridge, separating the efferent passages. The plates are equal to, if they do not surpass, any that have ever been published for this class. Nearly all the figures are copied from photographs made by the author. The following are new species:

Gelasimus heterophthalmus, G. heteropleurus, G. princeps, G. armatus, G. ornatus, G. pugnax, G. rapax, G. mordax, G. gibbosus, Cardiosoma crassum, Pseudothelphusa plana, Opisthocera, gen. nov., *O. Gilmanii, Epilobocera armata, Glyptograpsus,* gen. nov., *G. impressus, Sesarma sulcata, S. occidentalis, S. angusta, Prionoplax ciliatus, Euryplax politus, Glyptoplax,* gen. nov., *G. pugnax, Pinnotheres Lithodomi, Ostracotheres politus, Dissodactylus,* fam. et gen. nov., *D. nitidus.*

Those that are redescribed are as follows:

Gelasimus minax LeConte, *G. brevifrons* Stimp., *G. pugilator* Latr., *G. subcylindricus* Stimp., *G. Panamensis* Stimp., *Cardiosoma guanhumi* Latr., *C. quadratum* Sauss., *Epilobocera Cubensis* Stimp., *Dilocarcinus pictus* Edw., *Sesarma reticulata* Say, *Euryplax nitidus* Stimp., *Pinnotheres margarita* Smith, *Pinnaxodes Chilensis* Smith.

V.

13. *Monografia della Famiglia dei Pennatularii; per il* DOTT. SEBASTIANO RICHIARDI. From Archivio per la Zoologia l'Anatomia e la Fisiologia, Ser. II, vol. i, Turin, 1869, 8vo. with 14 folded plates.—In this memoir the author has given descriptions of all the genera and species of Pennatulacea hitherto discovered. When the specimens have not been seen by the author he has quoted the original descriptions, but in other cases the descriptions are quite detailed. The plates are very good and illustrate a large number of species, including a considerable number of new ones. One new genus, *Sceptonidium*, is described, which is allied to *Virgularia*. It has short fleshy pinnæ, with a wide naked space behind; the axis is angular. The only species is *S. mosam-*

bicanum. He reunites the genus, *Leioptilum*, to *Pennatula*, but recognizes most of the other generic divisions that have been proposed. Of *Pennatula* he describes 7 species, including one that is new, *P. Targionii*, locality unknown; of *Pteroides*, 27 species, including the following new ones: *P. Grayi* (=*P. grisea* Esper), locality unknown, *P. Vogtii*, *P. Cornaliæ*, *P. Clausii*, Mediterranean, *P. Pancerii*, locality unknown; of *Sarcoptilus* one, *S. grandis* Gray; of *Ptilosarcus* two, *P. Gurneyi* and *P. sinuosus* Gray; of *Halisceptrum* one; of *Scytalium* one; of *Stylatula* 5 species; *S. finnmarchica* (Sars sp.), *S. gracilis* V., *S. elongata* V., *S. multiflora* (Kner, sp.), *S. elegans* (Danielsen sp.); of *Virgularia* 8 species, including two new ones, *V. Leuckartii*, North Sea, and *V. Köllikerii*, Mozambique; of *Lygus* one species; of *Crinillum* one; of *Funiculina* 3; of *Umbellularia* one; of *Kophobelemnon* 3; of *Lituaria* 2; of *Cavernularia* 5, including *C. Haimeii* and *C. Defilippii*, two new species from unknown localities; of *Veretillum* 6; of *Renilla* 3, *R. reniformis*, *R. violacea* Q. and G., and *R. sinuata* Gray, the last from the Philippines.

In the genus *Renilla* the author is certainly at fault, owing no doubt to lack of specimens of some of our American species. To *R. reniformis* he unites *R. peltata* V., *R. Danæ* V., and *R. amethystina* V., the last from the Panamian fauna, the others Atlantic. Neither of these approach the true *reniformis* of the Carolina coasts, of which I have examined hundreds of specimens in all states of preservation. The latter never grows so large as either of the three, but has larger polyps and many other differences. The three species referred to are all more nearly allied to *R. violacea* than to *R. reniformis.* There can be no doubt but that these three species are all distinct, one from another; it is possible that *R. Danæ* may be identical with *R. violacea*, though it does not seem probable. The others are beyond doubt good species. To *R. violacea* he unites *R. patula* Verrill. Between the two forms there are certain resemblances and they may possibly prove to be the same, but I have seen no Brazilian specimens that appear to be identical with *R. patula.* In the Museum of Yale College and the Museum of Comparative Zoölogy I have studied five distinct American species, and admitting that one may be identical with *R. violacea*, no further reduction seems admissible. It seems quite probable, however, that the number of species of *Pteroides* might be considerably reduced by a careful study of all the original specimens. A. E. V.

14. *The Butterflies of North America*, with colored drawings and descriptions; by Wm. H. Edwards. Part 5. Philadelphia, Decem., 1869.—Number five of this beautiful work has been considerably delayed, on account of the plates, and was not actually published until April. The plates are excellent, and well sustain the character of the work. The following species are illustrated: *Argynnis Edwardsii; Colias Eurydice; Limenitis Lorquini; Grapta Faunus; Lycæna pseudargiolus; L. neglecta.* The Synopsis of North American Butterflies includes the species of *Nathalis, Anthocaris, Callidryas, Gonepteryx.* V.

IV. ASTRONOMY.

1. *Elements of Felicitas* (109), *from observations of the first opposition;* by WM. A. ROGERS. (Communicated for this Journal, and dated Alfred Observatory, Alfred Center, N. Y., April 12, 1870).—From my last Elements, published in the *Astronomische Nachrichten*, the following normal places were obtained, the deviations from the Ephemeris being found in the columns marked $\Delta\alpha$ (C—O), $\Delta\delta$ (C—O).

The observations of Hamilton College, Washington, and Chicago, were kindly communicated in advance of publication.

Date. W. M. T.	α ... δ (° ′ ″)	Δα (C—O) ″	Δδ (C—O) ″	Observations.
Oct. 9·0	14 9 6·0 + 9 36 4·52	—1·9	+0·2	Hamilton Col. (9). Alfred (3). Chicago (2).
Oct. 29·0	9 35 51·6 + 9 52 17·8	—1·7	—2·8	H. C. (4). Washington (3). Alfred (7).
Nov. 10·0	8 0 26·2 +10 9 51·3	+0·9	—2·8	Wash. (5). Hamburg (1). Bilk. (2). Madrid (6).
Nov. 28·0	8 06 08·3 +11 08 14·9	+2·6	—3·0	Lund (2). H. C. (2). Madrid (5). Alfred (8). Wash. (5). Hamburg (3).
Dec. 28	14 27 49·1 +14 21 37·8	+4·0	—3·6	Alfred (5). H. C. (1). Wash. (4).
1870. Jan. 22	24 06 03·4 +18 06 49·6	+6·0	—5·0	Alfred (15). H. C. (2). Wash. (4).
Feb. 22	39 36 26·9 +23 01 39·1	+5·0	—5·4	H. C. (1). Wash. (1). Alfred (5).

From the first, fourth and sixth places, the following elements were computed:—

Oct. 9·0 1869, W. M. T.

		° ′ ″
	M	339 0·5 45·21
Mean Eq. 1869·0.	π	55 56 03·25
	☊	4 56 04·35
	i	8 02 56·10
	φ	17 27 62·67
	log. a	·4304068
	μ	802″·4102

These elements represent the normals thus:—

		Δα (C—O)	Δδ (C—O)
1869.	Oct. 9.	—0·1″	+0·6″
	Oct. 29.	—0·4	—0·6
	Nov. 10.	+1·0	+0·2
	Nov. 28.	+0·4	+1·1
	Dec. 28.	—1·0	+1·2
1870.	Jan. 22.	+0·1	+0·9
	Feb. 22.	+0·0	+1·6

2. *On the Periods of certain Meteoric Rings;* by DANIEL KIRKWOOD. (Proc. Amer. Phil. Soc., March, 1870.)—(1.) *The Meteors of April 20th.*—In the Astronomische Nachrichten, No. 1632, Dr. Weiss called attention to the fact that the orbit of the first comet of 1861 very nearly intersects that of the earth, in longitude 210°; the point passed by the latter at the epoch of the April meteoric shower. A relation between the meteors and the comet, similar to that recently detected between the November meteors and the comet of 1866, was thus suggested as probable. Is this hypothesis in harmony with facts? and if not, are our present data sufficient for determining with any reasonable probability, the true period of the April meteors?

Dates of the April Shower.—Professor Newton selects the following from Quetelet's Catalogue as belonging to this period:*

1.	B. C.	687,	4.	A. D.	1093, '4 '5, and '6
2.	"	15,	5.	"	1122, '3
3.	A. D.	582,	6.	"	1803.

Period of the First Comet of 1861.—The elements of this body were computed by Oppolzer, who assigned it a period of 415 y. 4. Now while it is true that the interval from B. C. 687 to A. D. 1803, is very nearly equal to 6 periods of 415 years, the slightest examination will show that this period does not harmonize with *any of the intermediate dates.* This fact, then, without further discussion, seems fatal to the hypothesis that the period of the meteors is nearly equal to that of the comet.

What is the probable period of the ring?—The showers of 1093—6 and 1122—3 at once suggest a period of from 26 to 30 years. The nodal passage of the densest portion of the ring at the former epoch may be placed any where between 1093 and 1096, and that of the latter, in either 1122 or 1123. The entire interval from B. C. 687 to A. D. 1803 is 2490 years, or 88 periods of 28·295 y. each; and the known dates are all satisfied by the following scheme:

B. C.	687 to	B. C.	15	672·000 years	= 24	periods of	28·000	y. each.
"	15 to	A. D.	582	597·000 "	= 21	"	28·429	"
A. D.	582 to	"	1093·714	511·714 "	= 18	"	28·429	"
"	1093·714 to	"	1122·143	28·429 "	= 1	"	28·429	"
"	1122·143 to	"	1803	680·857 "	= 24	"	28·369	"

These coincidences indicate a period of about 28⅓† years, corresponding to an ellipse whose major axis is 18·59. Hence the distance of the aphelion is very nearly equal to the mean distance of Uranus. It will also be observed that the time of revolution, which seems to have been somewhat lengthened about the Christian era, was previously one-third of the period of Uranus.

(2.) *The Meteors of December 11th–13th.*—In the catalogue of Quetelet we find the four following extraordinary displays which belong undoubtedly to this period. Observations made in England, 1862, indicate also a more than ordinary number of meteors at the December epoch in that year.

* This Journal, July, 1863.

† Herrick assigned a value of 27 years. See this Journal, April, 1841, p. 365.

1. A. D. 901. "The whole hemisphere was filled with those meteors called falling stars, the ninth of Dhu'lhajja, (288th year of the Hegira) from midnight till morning, to the great surprise of the beholders, in Egypt."—*Modern part of the Universal History*, 8vo, vol. ii, p. 281. Lond. 1780. The date of this phenomenon corresponds to the December epoch, A. D. 901.

2. 930. "Averse remarquable d'ètoiles filantes en Chine."

3. 1571. "On vit à Zurich 'du feu tomber du ciel'".

4. 1830, 1833, and 1836. The maximum seems to have occurred in 1833, when as many as ten meteors were seen simultaneously. "Dans la nuit du 11 au 12 décembre, on vit à Parme une grande quantité d'étoiles filantes de différentes grandeurs, qui se dirigeaient presque toutes avec une grande vitesse vers le SSE. A 10 heures et ¼, entre les seules constellations du Bélier et du Taureau, on en compta environ une dizaine."

5. (Doubtful.) 1861, 1862, and 1863. Maximum probably in 1862. The meteors at this return were far from being comparable in numbers with the ancient displays. The shower, however, was distinctly observed. R. P. Greg, Esq., of Manchester, England, says the period for December 10th–12th was, in 1862, "exceedingly well defined." *

These dates indicate a period of about 29⅛ years. Thus:

901 to 930	1 period	of 29·000 years.
930 to 1571	22 periods	of 29·136 years.
1571 to 1833	9 periods	of 29·111 years.
1833 to 1862	1 period	of 29·000 years.

(3). *The Meteors of October 15th–21st.* The showers of the following years (see Quetelet's Catalogue) belong to this epoch:

1. 288. "Apparition en Chine."

2. 1436 and 1439. In each year a remarkable apparition was observed in China.

3. 1743. (Quoted from Herrick, in this Journal for April, 1841). "A clear night, great shooting of stars between 9 and 10 o'clock, all shot from S.W. to N.E. [Qu. N.E. to S.W. ?] One like a comet in the meridian very large, and like fire, with a long broad train after it, which lasted several minutes; after that was a train like a row of thick small stars for twenty minutes together, which dipped N."

4. 1798. "Brandès marque, à Goettingue, un grand nombre d'étoiles filantes dans les observations simultanèes qu' il fait avec Benzenberg."

These dates indicate a period of about 27½ years:

288 to 1439	42 periods	of 27·405	years each.
1439 to 1743	11 "	27·636	"
1743 to 1798	2 "	27·500	"

If these periods are correct, it is a remarkable coincidence that the aphelion distances of the meteoric rings of April 18th—20th, October 15th—21st, November 14th, and December 11th—13th, as well as those of the comets 1866 (i), and 1867 (i), are all nearly equal to the mean distance of Uranus.

* This Journal, May, 1863, p. 461.

3. *Abstracts from the Report of the Council of the Royal Astronomical Society*, at the fifteenth Annual meeting, Feb. 1870.

(1.) *Work done with the Photoheliograph at the Kew Observatory.*—The first instalment of the measurements and reductions of the Kew Sun-pictures taken during the two years 1862 and 1863, containing also the areas of the observed groups and an explanation of the methods followed in the working out of the observations, have been published in the last volume of the Transactions of the Royal Society. Nearly 150 separate copies of the paper, printed partly at the private expense of Mr. Warren De La Rue, were distributed chiefly to foreign observatories, scientific institutions, and distinguished astronomers and physicists.

The second instalment, containing the heliographic positions of the Sun-spots observed from the beginning of 1864 to the end of 1866, is nearly ready, and will be presented to the Royal Society at an early date during the present session.

Some investigations were also made last year on the influence which a refracting medium of considerable density would have on the apparent size and figure of the Sun, and the time of rotation, as calculated from spots at different latitudes. The preliminary discussion has led to the conviction that a comparison of the times of rotation, as derived from spots while they are near the limb, with those deduced from the same spots when near the center, will throw much light on several important questions connected with solar physics. The matter will be exhaustively investigated in the general discussion of the Kew results.

During the present year it is intended to bring, if possible, the work of the measurements up to date. The scarcity of spots during 1867 and 1868 was such, that the pictures of these years may be measured in a comparatively short time; and it is hoped that by completing, by the end of this year, the observations made up to at least the end of 1869, that the greater part of the succeeding years may be devoted to as careful a discussion of the whole work as is required by the importance of the astronomical and physical problems involved in it.

Messrs. De La Rue, Stewart, and Loewy, state that the reductions of Hofrath Schwabe's observations are now finished. By comparing his observations with those taken by Carrington, and also with the Sun-pictures taken at Kew, they arrived at very favorable conclusions regarding the accuracy of the delineations of the distinguished German observer. Beginning with the year 1832, they have measured the spotted area of all his pictures up to the time when Carrington's series commenced. From the results obtained they have, first of all, deduced fortnightly views, and in the next place, in order to get rid of the more transitory fluctuations, they have taken a series of those monthly views corresponding to the middle and end of each month, from the beginning of 1832 till the end of May 1868. Putting these results into a graphical form, they have obtained a curve exhibiting only the irregularities of comparatively long periods, and from the curve by the ordinary method of equalization, they have deduced an equalized curve exhibiting the decimal period of solar disturbances.

They find therefrom the following epochs of maximum and minimum spotted area:—

Minimum	Nov. 28	1833	Minimum	April 21	1856
Maximum	Dec. 21	1836	Maximum	Oct. 7	1859
Minimum	Sept. 21	1843	Minimum	Feb. 14	1867
Maximum	Nov. 14	1847			

From these dates it will be perceived that (as has been already observed) the time between the minimum and maximum is always less than that between the maximum and next minimum.

It will also be noticed that the whole period is not always of uniform length; nevertheless, judging from what has gone before, they believe that they are perhaps entitled to conclude that the approaching minimum will not be delayed much beyond the end of this year. It ought also to be remarked that, in all the three series, the progression from maximum to minimum is not a simple progression, but exhibits in each case traces of a secondary maximum.

Finally, they have examined these results for traces of the action of the planets upon Sun-spots, and pursuing the method indicated in their preliminary researches, they derived the following table, as exhibiting the evidence deduced from all the observations between 1832 and 1868:—

Relative Planetary Separation.	Excess or Deficiency of Spotted Area. Jupiter and Venus	Mars and Mercury.
Between 0° and 30°	+ 881	+1675
30 " 60	− 60	− 139
60 " 90	− 452	−1665
90 " 120	− 579	−2355
120 " 150	− 705	−2318
150 " 280	− 759	−1604
180 " 210	− 893	− 481
210 " 240	− 752	+ 547
240 " 270	− 263	+ 431
270 " 300	+ 70	+ 228
300 " 330	+ 480	+1318
330 " 0	+1134	+2283

From this table there appears to be an excess of solar activity when either *Jupiter* and *Venus* or *Mars* and *Mercury* are together, and a deficiency when they are 180° apart. We see also that the progression of the numbers is regular in each case and very similar in the one case to what it is in the other.

(2.) *Spectrum Analysis.*—Our Fellow, Mr. Lockyer, has pursued with great diligence and success his spectroscopic researches on the Sun. Since the last Report he has found that several other substances besides hydrogen are occasionally to be detected above the photosphere, namely, sodium, barium, magnesium, and iron. The presence of the bright lines of these substances rising above the photosphere, and associated with the bright lines of hydrogen, Mr. Lockyer regards as indicating a state of disturbance of the solar matter, greater than was present at the time of his earlier observations. From a slight alteration in refrangibility of the bright lines of hydrogen, as shown by their want of perfect coincidence with the corresponding lines of absorption, Mr. Lockyer believes that he has evidence of rapid currents in the solar matter, sometimes attaining a velocity of 40 miles per second in a vertical direction, and a velocity of 120 miles per second in a horizontal or cyclonic direction. He considers that his observations support the conclusion that "the chromosphere and the photosphere form the true atmosphere of the Sun, and that under ordinary circumstances, the absorption is continuous from the top of the chromosphere to the bottom of the photosphere." In these observations Mr. Lockyer is accumulating a store of facts, upon which we may hope to base a more complete theory of the constitution of the Sun than we now possess.

(3.) *Lunar Radiation.*—After stating the results of Lord Rosse's observations upon Lunar Radiation which are given in this Journal, (vol. xlviii, p. 436), the council go on to say:

Some later observations have been made upon the same subject in Paris, respectively by M. Baille, at the Ecole Polytechnique, and M. Marié-Davy at the Paris Observatory. The former employed a concave mirror of 39 centimeters aperture to condense the Moon's rays upon his pile, and also made use of a Thomson's galvanometer. The one conclusion at which he arrived was, that the full Moon, at Paris and in the summer months, gave as much heat to his pile as a radiating surface 6·5 centimeters square, maintained at boiling-water temperature and placed at a distance of 35 meters. M. Marié-Davy has published results of two series of measures secured during the lunations of October and November last. The first were made with a pile attached to a 9-inch equatorial refractor, the second with an 8-inch mirror; the object-glass in the former case having been found to intercept a large proportion of the heat-rays. M. Marié-Davy's measures confirm those of Lord Rosse. They show that the heating effect of the Moon increases with the illumination of the visible disk. Between October 9, when the Moon was four days old, and October 20, when it was full, the measured heat of the condensed beam of moonlight increased from 0°·00017 (centigrade) to 0°·00287. If this last number be divided by the ratio of the area of the concentrated image to the area of the object-glass, we have twelve-millionths of a centigrade degree as the direct heating power of the full Moon at the Earth's surface. This is the result given by the object-glass, that afforded by the mirror is about six times as great. It will be seen that M. Marié-Davy has converted his galvanometer indications into centigrade equivalents: how this conversion was effected, and how the constancy of the scale indications is secured, if it is secured, we are not informed. He confirms Lord Rosse's inference that the proportion of solar to lunar radiation is about as 80000 to 1, and likewise concludes that the Moon imparts to us no heat from an internal or cosmical source. Further, he infers that the diffusive power of the lunar surface is considerable, at least equal to that of the least colored of terrestrial rocks; and he finds that the lunar heat by reason of its large percentage of obscure rays is far more impressionable by atmospheric humidity than that from the Sun.

It will be remembered that Professor Smyth, in his Teneriffe experiments, determined the heating power of the full Moon to be equal to one-third of that of a Price's candle at a distance of 14 feet 9 inches. M. Marié-Davy finds that such a candle at such a distance affects his pile to the extent of 0°·00075 centigrade, which he conceives to be the heating power of the Moon upon the summit of Teneriffe, upon the supposition that the heat emitted by the respective candle-flames was sensibly the same.

(4.) *Heating Power of the Stars.*—The experiments upon this subject, commenced by Mr. Stone with the great Equatorial of the Greenwich Observatory, in the year 1868, and mentioned in the last Annual Report, were continued as weather permitted during 1869. In pursuing them, Mr. Stone was led to the construction of a thermopile which there is good reason to believe will prove of value in thermometric researches other than those of the class for which it was specially prepared. His early trials convinced him that it was almost impossible to distinguish the feeble currents generated by stellar heat from the grosser effects produced upon the pile by exposure of one face within the telescope tube and the protection of the other face outside the telescope tube. It was evident that to maintain the pile in thermal equilibrium its two faces must be exposed to precisely similar atmospheric influences. Mr. Stone therefore resorted to what in effect may be described as a horse-shoe pile, the two faces of which being similarly presented to the object-glass of the telescope were affected alike by disturbing causes, whether these took the form of draughts of air or cooling of the metals of the pile by radiation. By this arrangement the whole heat of a star's image cast upon either face of the pile manifested itself *per se.* Decided indications of heat from *Arcturus* and *α Lyræ* were thus obtained on several nights. The amounts were measured by a reflecting galvanometer; and by a somewhat tedious process the galvanometer indications were converted into Fahrenheit-scale equivalents. It was found that the heating effect of *Arcturus*, after allowing for absorption by the object-glass, was 0·00000137 of a Fahrenheit degree; that of *α Lyræ* being about two-thirds of this amount. Otherwise expressed, the heat from *Arcturus*, at an altitude of 25° at Greenwich, is about equal to that from a three-inch cube of boiling water at a distance of 400 yards, while from *α Lyræ* it is equal to that from the same cube at 600 yards. Mr. Stone conceives that the difference of heating power may be connected in cause with difference of color. He finds that the manifested heat diminishes rapidly as the amount of moisture in the air increases, and that all sensible effect is cut off by the slightest cloud or haze. The details of the investigation are published in the *Proceedings of the Royal Society* for January, 1870.

(5.) *Transit of Venus*, 1874.—The preparatory arrangements, for the observations of the transit of *Venus*, 1874, are sufficiently advanced to encourage us to expect most important additions to the data already collected for the determination of our fundamental astronomical unit of length. The British Government has already placed at the disposal of the Astronomer Royal sufficient funds for the equipment of five stations, each with an Altazimuth and Transit, for the determination of longitude and local time, and with two telescopes, one of which is to be of six inches aperture, and to be provided with driving power. Four of the larger instruments have already been obtained, and the Transits and Altazimuths are in actual progress in the manufactory of Messrs. Troughton and Simms. The second telescope at each station will be of four inches aperture.

The present intention appears to be to place the British observers at Kerguelen's Island, Oahu, Auckland in New Zealand, Alexandria, and Rodriguez.

A Commission, consisting of Admiral Paris, MM. Faye, Laugier, Villarceau, and Puiseux, has reported to the Bureau des Longitudes that it would be particularly desirable for the French astronomers to occupy the Islands of St. Paul and Amsterdam, Yokohama, Tahiti, Nouméa, Mascate and Suez.

The North German astronomers have referred the consideration of the action which they should urge upon their Government, to a Committee, of whom the illustrious astronomer of Gotha was elected chairman.

This Committee appear to lay great stress upon the employment of heliometers for fixing the relative position of *Venus* on the Sun at the different stations.

Equatorials with driving power for the eye-observers were to be of 6 feet focal length and 52 lines aperture. The employment of photography and spectroscopic observations was discussed. The chief objection to the employment of photography appeared to be in the question of expense, although Professor Argelander was not satisfied with the degree of accuracy which might be expected from it. The further consideration of this question was, however, deferred to a sub-committee. Spectroscopic observations were proposed only to indicate the approach of the planet for the observation of external contacts. The Committee recommended that the Government be urged to fit out four expeditions,—two to the North and two to the South. The stations specially referred to as favorable were, Nertschinsk, Hakodadi, Kerguelen, Edwards', Crozet's and Auckland Islands, and in certain respects Mauritius.

The Russian territories offer most valuable positions for the location of observers. These stations are certain to be well occupied by the Russian astronomers. The Director of the Imperial Observatory at Pulkova has already secured a Committee for the consideration of a proposition to establish a chain of observers across the country from Kamtschatka to the Black Sea, at intervals of about 100 miles. This appears desirable on account of uncertainties connected with the atmospheric conditions in the month of December.

It is to be hoped that, for the same reason, there will not be a too great crowding of the observers toward one or two points, in other regions, to the exclusion of others of nearly equal importance; and that, in this matter at least, after the best consideration has been given the subject, we may all adopt instruments of not very unequal power, and attempt to make the same class of observations in the same way. Uniformity in these observations means success; want of uniformity, comparative failure.

3. *Star-Drift;* by R. A. Proctor.—With referrence to the accompanying account of my paper on this subject, recently communicated to the Royal Society, it is to be remarked that the interest, if any, attaching to my results must be founded on the way in which they bear on received theories respecting the distribution of the fixed stars. It is quite evident that according to the views usually accepted, the stars which appear in any part of the heavens must be regarded as situated at very different distances from the eye; the faintest nine or ten times farther from us, at the very least, than the brightest, and the different stars altogether too far apart to exert any influence on each other. Indeed, whatever theory we may hold respecting stellar distribution, regarded generally, we must be prepared to recognize in the stars seen toward any part of the sky, objects which lie at very different distances. And regarding these objects as severally in motion, we must be prepared to find in general the utmost diversity, not only as respects the direction of the apparent motions of the stars, but also as respects the magnitude of these motions. It is only when one has adopted the theory that the stars are grouped according to special laws of aggregation, that one would be led to anticipate that here and there, almost as by accident, so to speak, some indications of their grouping might be discoverable in the characteristics of the stellar proper motions. Although I had become firmly convinced that the stars are not distributed throughout space with any approach to that general uniformity insisted on by many astronomers, I had very little hope that a suggestion I threw out a year ago in the pages of the *Student*, that the stellar proper motions if examined carefully might afford evidence in favor of my views, would be confirmed in any very distinct manner if the method I had pointed out should ever be applied. I knew that a certain community of motion in the constellation Taurus had led Mädler to important, but as I judged incorrect conclusions as to the nature of the stellar motions; but I also knew that that community of motion was one which could only be appreciated by the few who had convinced themselves of what was to be *expected* if the stars were uniformly distributed. I had an impression at that time that Mädler had examined the stellar proper motions over

the whole of the northern hemisphere, and that it was the exceptional community of proper motion in Taurus which had led him to form his well-known theory respecting a central sun. It was only when I was reminded that he had in fact examined the stellar proper motions in the neighborhood of Taurus alone, having been led by independent considerations to regard that neighborhood as that within which a central sun was to be looked for, that I was encouraged to map down all the recognized proper motions. To my surprise I found that in Gemini, Cancer, and Leo, a community of motion far more striking than that noticed by Mädler in Taurus was to be recognized; and further, that though in other directions, as I had expected, stellar motions belonging to different depths in space were intermixed, it was yet possible to trace out laws of association indicating the existence of drifting star-groups in these directions also.

I lay very little stress on the indications which have led me to name the great double cluster in Perseus as more likely to be an important center of motion than the Pleiades. But it is worthy of mention that Mädler required a star on the Milky Way as the center of the galaxy, and Alcyone does *not* lie on the Milky Way; he required his center to lie ninety degrees from the apex of the solar motion, and Alcyone does *not* lie ninety degrees from the mean of the last determinations of that point. The great cluster in Perseus fulfills both conditions in the most perfect manner.

A careful examination of the proper motions of all the fixed stars in the catalogues published by Messrs. Main and Stone (Memoirs of the Royal Astronomical Society, vols. xxviii and and xxxiii) has led Mr. Proctor to the conclusion that in parts of the heavens the stars exhibit a well-marked tendency to drift in a definite direction. "In the catalogues of proper motions, owing to the way in which the stars are arranged, this tendency is masked; but when the proper motions are indicated in maps, by affixing to each star a small arrow whose length and direction indicate the magnitude and direction of the star's proper motion, the star-drift (as the phenomenon may be termed) becomes very evident. It is worthy of notice that Mädler, having been led by certain considerations to examine the neighborhood of the Pleiades for traces of a community of proper motion, founded on the drift he actually found in Taurus his well known theory that Alcyone (the *lucida* of the Pleiades) is the common center around which the sidereal system is moving. But in reality the community of motion in Taurus is only a single instance, and not the most striking that might be pointed out, of a characteristic which may be recognized in many regions of the heavens. In Gemini and Cancer there is a much more striking drift towards the southeast, the drift in Taurus being towards the southwest. In the constellation Leo, there is also a well-marked drift, in this case toward Cancer.

"These particular instances of star-drift are not the less remarkable, that the stars are drifting almost exactly in the direction due to the proper motion which has been assigned to the sun, because the recent researches of the Astronomer Royal have abundantly proved that the apparent proper motions of the stars are not to be recognized as principally due to the sun's motion. Mr. Stone has shown even that we must assign to the stars a larger proper motion, on the average, than that which the sun possesses. Looking, therefore, on the stars as severally in motion, with velocities exceeding the sun's on the average, it cannot but be looked upon as highly significant that in any large region of the heavens there should be a community of motion such as I have described. We seem compelled to look upon the the stars which exhibit such community of motion as forming a distinct system, the members of which are associated indeed with the galactic system, but are much more intimately related to each other. In other parts of the heavens, however, there are instances of a star-drift opposed to the direction due to the solar motion. A remarkable instance may be recognized among the seven bright stars of Ursa Major. Of these, the stars β, γ, δ, ϵ, and ζ are all drifting in the same direction, and almost exactly at the same rate towards the 'apex of the solar motion,' that is, the point *from* which all the motions due to the sun's translation in space should be directed. If these five stars, indeed, form a system (and I can see no other reasonable explanation of so singular a community of motion), the mind is lost in contemplating the immensity of the periods which the revolutions of the components of the system must occupy. Mädler had already assigned to the revolution of Alcor around Mizar (ζ Ursæ) a period of more than 7000 years. But if these stars, which appear so close to the naked eye, have a period of such length, what must be the cyclic periods of the stars which cover a range of several degrees upon the heavens? In like manner the stars α, β, and γ Arietis appear to form a single system, though the motion of α is not absolutely coincident either in magnitude or direction with that of β and γ, which are moving on absolutely parallel lines with equal velocity. There are many other interesting cases of the same kind." The author hopes soon to be able to lay before the Royal Society a pair of maps in which all the well-recognized proper motions in both hemispheres are exhibited on the stereographic projection. In the same maps also the effects due to the solar motion are exhibited by means of great circles through the apex of the solar motion, and small circles or parallels having that apex for a pole. The star-drift described by Mr. Proctor serves to explain several phenomena which had hitherto been thought very perplexing. In the first place, it accounts for the small effect which the correction due to the solar motion has been found to have in diminishing the sums of the squares of the stellar proper motions. Again, it explains the fact that many double stars which have a common proper motion, appear to have no motion of revolution around each other; for clearly two members of a drifting system might appear to form a close double, and yet be in reality far apart and travelling, not around each other, but around the center of gravity of the much larger system they form part of

While mapping the proper motions of the stars, Mr. Proctor has been led to notice that the rich cluster around χ Persei falls almost exactly on the intersection of the Milky Way with the great circle which may be termed the equator of the solar motion; that is, the great circle having the apex of the sun's motion as a pole. This circumstance points to that remarkable cluster, rather than to the Pleiades, as the center of the sidereal system, if indeed that system has a center cognizable by us. When we remember that for every fixed star in the Pleiades there are hundreds in the great cluster in Perseus, the latter will seem the worthier region to be the center of motion. The author is disposed, however, to regard the cluster in Perseus as the center of a portion of the sidereal system, rather than as the common center of the Galaxy.—*Nature*, No. 8, March 3.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *National Academy of Sciences: List of Papers read at the Meeting in April*, 1870, *at Washington, D. C.*—

On the measurement of wave-lengths by means of indices of refraction; by Dr. Wolcott Gibbs.

On the coming Transits of Venus, and the mode of observing them; by Prof. Simon Newcomb.

Meridional arcs measured in connection with the U. S. Coast Survey; by Prof. J. E. Hilgard.

The Relations of the four Archetypes of structure of the Animal Kingdom, as parts of one Life System; by Prof. A. Guyot.

Observations on the Measurement and Iconography of Crania; by Dr. Geo. A. Otis, U. S. A.

The northmen in Greenland; by Dr. I. I. Hayes.

Considerations on the apparent inequalities of long period in the moon's mean motion, and on the possible variability of the sidereal day; by Prof. Simon Newcomb.

On the deviation of Compasses in iron-clad ships; by Prof. Wm. Harkness, U. S. N.

On Artificial deformation of Skulls; by Dr. Geo. A. Otis, U. S. A.

On the proposed Astronomical observatory in the Argentine Republic; by Dr. B. A. Gould.

Scientific operations now in progress by the Smithsonian Institution; by Prof. Joseph Henry.

On the comparison of Barometers; by Dr. B. F. Craig.

On the influence of the interior structure of the earth, on precession and nutation; by Gen. J. G. Barnard, U. S. A.

Reduction of photographic observations of Præsepe; by Dr. B. A. Gould.

On the Lignites of Western America; by Dr. J. S. Newberry.

On the use of certain Artificial lights in photographing objects as seen with the microscope; by Dr. J. J. Woodward, U. S. A.

On the classification of Clouds; by Prof. Poey.

New breeds of Hardy Silk Worms, which feed on the "Ailanthus and Oaks," and the importance of their introduction into the country as a future industry; by J. Q. A. Warren.

On some of the phenomena attending the great tornado thunder-storm of Iowa and Illinois, of June 3rd, 1860; by Wm. L. Nicholson.

Astronomical Photography; by Lewis M. Rutherfurd.

Classification of Mammals; by Theodore Gill.

Redemption periods of life-annuities and reversions; by E. B. Elliot.

Description of a new binocular for the Microscope to be used with high powers; by F. A. P. Barnard.

Report on Metric Standards; by J. E. Hilgard.

The Basalts of Oregon, Washington, and Idaho; by R. W. Raymond.

On the polarization of the atmosphere; by Prof. Poey.

A new form of Quarternions; by Benjamin Peirce.

2. *The Mean Pressure of the Barometer and the Prevailing Winds over the Globe for the Months and for the Year.* Part II; by ALEXANDER BUCHAN, M.A., F.R.S.E., Secretary of the Scottish Meteorological Society, &c. 54 pp. 4to; (from the transactions of the Roy. Soc. of Edinburgh, vol. xxv.)—This memoir presents the results of a most important research with regard to the lines of equal barometric pressure, *or isobaric lines*, over the globe. The results as regards the months of January and July are given by the author on maps in his Handy Book on Meteorology published two years since. The paper here issued contains the maps for each of the twelve months, and also another for the means of the year. We cite a few paragraphs giving some of the conclusions.

Distribution of Atmospheric Pressure, in December, January, and February.—In these months, the highest pressures are grouped over the land portions of the northern hemisphere, and the larger the extent of the land the greater is the pressure. The area of high barometer (30 inches and upward) embraces nearly all Asia; all Europe, south of the North and Baltic Seas; the North Atlantic, between 15° and 45° lat.; the West Indies; North America, except the north and northwest; and the North Pacific, between 8° and 24° lat. There are also two regions of high pressure of comparatively small extent—the one in the South Atlantic, and the other in the South Pacific.

The regions of low pressure are the northern portions of the North Atlantic and of the North Pacific, including portions of the continents adjoining; the belt of low pressure in the equatorial regions, towards which the trade winds blow; and the remarkable depression in the Antarctic regions, which probably is subject to little variation throughout the year.

In March, pressure diminishes over Asia, the middle and south of Europe, and the United States of America. Everywhere else, except in the tropics, it is rising. This rise of pressure is most apparent in the temperate regions of the southern hemisphere. In the north of the Atlantic it is rapidly rising, the average pressure in Iceland now being 29·609 inches, thus showing an increase of 0·34 inch as compared with January.

In April, the heavy lines showing a pressure above the average have now all but left Asia, Europe, and the United States, and the isobars of 30 inches bound a belt of high pressure which completely encircles the globe in the south temperate zone. Pressure continues to rise in the north of the Atlantic, and to the north of North America, and it is probable that a space of high pressure (at least 30 inches) surrounds the North Pole. In this month pressure is more equally distributed over the globe than in any other month; for, excepting the Antarctic Ocean, it scarcely rises anywhere above 30·1 inches, or falls below 29·8 inches.

In May, in the north of Europe, in Greenland, and in the north of America, atmospheric pressure attains the maximum of the year. Pressure continues to increase over the south temperate zone, and the *isobar* of 30·1 inches now nearly extends round the globe. At this time the highest pressure in the southern hemisphere occurs in the southeast of Australia, where, at Deniliquin, it is 30·185 inches. Pressure is rapidly falling over Asia and the United States.

In June, July and August, pressure falls in the central regions of Asia to about 29·5 inches. In this season this great diminution of pressure, which may be regarded as absolutely determining the summer climates of Asia, reaches its lowest point. Pressure falls also in the interior of North America, where at Utah, Great Salt Lake, it is only about 29·7 inches. The annual maximum of the south temperate zone is attained in these months. The isobar of 30·1 inches goes completely round the globe, and a still higher pressure prevails over the south of Africa, and over those parts of the ocean immediately to the west and east of it. In these months the arrangement of the isobars may be regarded as being, generally speaking, reversed from that of December, January, and February, and on this account a comparison of these two groups of months is very instructive.

From this period, pressures increase over the continents of the northern hemisphere, and diminish over the south temperate zone, till the distribution of pressure is regained, which has been already shown to prevail during the winter months. *In September and October*, an interesting feature of these lines is a very rapid diminution of the pressure indicated as taking place in the north of the Atlantic and adjoining regions. This is the season of the year when the first great decrease of temperature takes place, which is accompanied by heavy rains and furious storms. The increase of pressure in Sweden in October, taken in connection with the simultaneous decrease in Greenland, Iceland, north of Norway, and the British Islands, is interesting, as bearing on the transference of masses of the atmosphere from one region to another.

In November, pressure rises considerably over the continents of the northern hemisphere, and falls in the south temperate zone; and the belt of low pressure in the equatorial regions may be regarded as now passing completely round the globe. This belt, towards which the trades on each side of the equator blow, does not occur in the summer months in the Indian Ocean; but, on the contrary, there is a continuous diminution of pressure northward, from Australia and Mauritius to the interior of Asia. It will be seen that in November, as compared with October, the isobars have advanced a little northward from the British Isles to Iceland, and eastward from Baffin's Bay to Iceland, thus indicating a general increase of pressure over the north of the Atlantic and regions adjoining. Coincident with this increase of pressure, there occurs a diminution of pressure to the southeast of it, including Austria, Italy, and countries adjoining the Mediterranean; and in the Atlantic to the south of it, from about latitude 45° to 15°N. Probably these extensive oscillations of the pressure are parts of one general movement of the atmosphere, which in one of its manifestations has been long known to meteorologists under the name of the great November wave, but of which no very satisfactory account has yet been given.

In addition to these changes in the monthly distribution of the pressure, it is probable that a system of low pressures traverses the continent of Africa, following the sun's course; but since the grounds of this supposition have been recently laid before the Society, in a paper on "The Determination of Heights, chiefly in the the Interior of Continents, by Observations of Atmospheric Pressure,"* it is not necessary to reproduce them here. The probable pressure for the months is shown on the separate charts.

3. *Royal Society of London.*—Fifty-three candidates have offered themselves for the fellowship of the Royal Society during the present session, and in June next fifteen out of the number will be elected.—*Athenæum*, March 12.

4. *Prizes for Comets.*—The Academy of Sciences at Vienna have offered eight gold medals for the discovery of as many comets during the coming three years.—*Athen., ibid.*

OBITUARY.—MAGNUS, of Berlin, the physicist, died in that city, on the 4th of April.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Hand Book of the Sulphur-Cure as applicable to the Vine disease in America, and diseases of Apple and other Fruit Trees;* by WILLIAM J. FLAGG, author of "Three Seasons in European Vineyards." 100 pp. 12mo. New York, 1870. (Harper & Brother).—Mr. Flagg is the proprietor of extensive vineyards in Ohio, and has devoted much study to the management of vines, in health and in disease. Those who have read his lively "Three Seasons" need not be told that he handles his theme with point and vivacity, as well as with a discriminating judgment. Mr. Flagg makes no claim to a scientific knowledge of microderms, but he clearly shows, 1st, that mildew in the grape is always due to a fungus growth, and 2d, that this fungus, whether *Oidium*, *Erysephe*, or another genus, is certainly destroyed by the early and thorough application of flour sulphur. Every cultivator who reads the 'Hand Book,' must at least accept the author's closing words, and "try it." It is probably a misprint which states the "gramme"

* Proceedings of the Roy. Soc. Edin., vol. vi, p. 465.

on p. 50 to be about 23 grains, in place of 15·43 grains. As it clearly appears that sulphur, in a very fine state of subdivision, is much preferred to even finely pulverized roll sulphur, ground in a mill, would it not be well to try the precipitated sulphur of the Pharmacopeia (*sulphur precipitatum*) "lac sulphur" or "milk of sulphur," which is an impalpable non-crystalline powder, and entirely free of the acid which contaminates flour sulphur, and which is often hurtful to the delicate leaves of the growing grape. Every farmer could prepare his own product.

2. *The Chemical Forces, Heat, Light, Electricity, with their applications to the expansion, liquefaction, and vaporization of Solids: the Steam Engine: Photography: Spectrum analysis: the Galvanic battery: Electro-plating: the Electrical illumination of Light-Houses: the Fire Alarm of Cities: the Atlantic Telegraph:* an Introduction to Chemical Physics, designed for the use of Academies, Colleges, and Medical Schools. Illustrated with numerous engravings, and containing copious lists of experiments, with directions for preparing them. By THOMAS RUGGLES PYNCHON, M.A., Scovill Professor of Chemistry and the Natural Sciences, Trinity College. 534 pp. 12mo. Hartford, 1870. (O. D. Case & Co.)—Prof. Pynchon's book is designed chiefly for a class of readers who would be unable to follow him with the aid of mathematics. "All matters of which a knowledge could equally well be obtained from any good treatise on Natural Philosophy, have been omitted," the author tells us in his Preface:—a statement which appears hardly sustained by the rather copious list of "subjects which have been most carefully elaborated," commencing with 'heat,' and embracing pretty much the usual range of physical topics. The work is very neatly printed, and while it is not well adapted to the accurate drill of the recitation room, it is a good *vade mecum* for a course of lectures on chemical physics, and for the use of the general reader, containing a large amount of useful and interesting information on various cognate physical subjects.

3. *The Life of John James Audubon, the Naturalist.* Edited by his WIDOW, with an introduction by JAMES GRANT WILSON. 443 pp. 12mo. New York, 1870. (G. P. Putnam & Son.)—This charming biographical sketch of Audubon is an abridgment of a much more extended memoir prepared by Mrs. Audubon, and sent in 1867 to a London publishing house, who employed Mr. Robert Buchanan to prepare a single volume containing about one-fifth of the original manuscript. The American edition contains some additions, and suppresses several objectionable passages inserted by the London editor. Audubon was a wonderful combination of artist, naturalist, and enthusiast, fused into an intense individuality by a strong will, and gilded by heroism and poesy.

American ornithology has always been fortunate in its historians and devotees, among whom the names Wilson, Nuttall and Audubon must always stand preëminent; and this loving tribute of a devoted wife, who was always the sympathizing companion of her husband, will revive in the present generation something of the admiration for the genius of Audubon, which his gentle voice and child-like simplicity ever kindled in his contemporaries.

Audubon kept a copious journal of his daily life, from which much of the present volume is drawn, and its perusal excites the hope that in due time we may see the entire work, of which this sketch may be considered as only the precursor. Inman's spirited portrait of Audubon, engraved by Hall, prefaces the volume, which is in all respects worthy the good taste of the publishers. S.

4. *A Physician's Problems;* by CHARLES ELAM, M.D. pp. 400, 12mo. 1869. Boston, (Fields, Osgood & Co.)—This is a carefully written and philosophical discussion of some of the most important 'Problems' which can engage the attention of the medical man. The list of topics discussed is sufficiently suggestive. I. Natural Heritage; II. On Degeneration in Man; III. On Moral and Criminal Epidemics; IV. Body; V. Mind; VI. Illusions and Hallucinations; the demon of Socrates; the amulet of Pascal; VII. On Somnambulism; VIII. Revery and Abstraction. This book addresses a much larger class of readers than that to which it is specially addressed, and while the author's views may not be universally accepted, his discussion of them is scholarly and always interesting. S.

Palæontology of the Geological Survey of New York, by James Hall. Vol. IV, Part 1. 428 pp. 4to, with 69 plates. Albany, N. Y. 1870.

Handbook of Zoology, with examples from Canadian species, recent and fossil. By J. W. Dawson. Part I.—Invertebrata, with 275 illustrations. 224 pp., 12mo. Montreal, 1870.

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*** Omitted in Index to last volume.**
Magnetite in the mica of Pennsbury, in reply to G. Rose, 360.

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