J. Ericsson

ANNUAL

OF

SCIENTIFIC DISCOVERY:

OR,

YEAR-BOOK OF FACTS IN SCIENCE AND ART

FOR 1863.

EXHIBITING THE

MOST IMPORTANT DISCOVERIES AND IMPROVEMENTS

IN

MECHANICS, USEFUL ARTS, NATURAL PHILOSOPHY, CHEMISTRY, ASTRONOMY, GEOLOGY, ZOOLOGY, BOTANY, MINERALOGY, METEOROLOGY, GEOGRAPHY, ANTIQUITIES, ETC.

TOGETHER WITH

NOTES ON THE PROGRESS OF SCIENCE DURING THE YEAR 1862; A LIST OF RECENT SCIENTIFIC PUBLICATIONS; OBITUARIES OF EMINENT SCIENTIFIC MEN, ETC.

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NOTES BY THE EDITOR

ON THE

PROGRESS OF SCIENCE FOR THE YEAR 1862.

No meeting of the American Association for the Promotion of Science took place during the past year, and the old organization of this body may probably be regarded as defunct.

The thirty-second annual meeting of the British Association for the Advancement of Science was held at Cambridge, October, 1862, Prof. Willis, of Cambridge, being in the chair. The meeting was less interesting, and far less numerously attended, than most of the former sessions of this body; and some of the discussions were in a measure acrimonious and personal. The annual address of the President, moreover, contained nothing particularly interesting to the general reader. The meeting for 1863 was appointed to be held at Newcastle-on-Tyne; Sir William Armstrong, of Armstrong gun notoriety, being elected President for the year.

A most ludicrous illustration of misapplied and mistaken zeal in the pursuit of science, which occurred at this meeting, is worthy of notice. A Rev. Dr. Mill read a very long paper, displaying extraordinary learning in Hebrew, Greek, and almost every language that could be brought in. The subject of it was an inscribed stone, found in Aberdeenshire, a county containing many of what are commonly called Druidical monuments. Dr. Mill read the inscription backwards, decided that the letters were Phœnician, and explained them by the corresponding letters of the Hebrew alphabet. According to his interpretation, it was a votive monument dedicated to Eshmùn, god of health (the Tyrian Esculapius), in gratitude for favors received during the "wandering exile of me thy servant," — the dedicator being "Han-Thanit-Zenaniah, magistrate, who is saturated with sorrow." Dr. Mill very learnedly discussed the question whether Han-Thanit-Zenaniah had suffered from disease or shipwreck, and whether his sorrow had been caused by the loss of companions, or friends, or relations. He discussed, also, the peculiarity of the word used in the signification of magistrate, and pointed out that he appeared to have been a man of consular dignity, who had commanded a ship or fleet which came to Britain, and that this and other circumstances pointed to the earlier period of the history of Tyre.

At the conlusion of the reading of the paper, another member, Mr. Wright, arose, and in a few words showed that the monument was sepulchral; that the inscription was not in Phœnician, but in rudely-formed Roman characters, and that its antiquity was of a period subsequent to what is usually termed the withdrawal of the Romans from Britain. He then read the inscription, which showed that the stone simply marked the burial place of some person named Constantine, and recorded his own name and that of his father.

Mr. William Fairbairn, the eminent engineer, who presided over the Section of Mechanical Science, thus expressed himself, in an opening address, on the importance of making instruction in the theory of steam and its applications an essential part of all general elementary education: —

"The general principles of the steam engine and the locomotive are, however, easily acquired, and in this age of steam it should, in my opinion, form a separate branch of education for the benefit of both sexes, to whom it would be highly advantageous. It is a branch of knowledge of deep importance to the present and rising generation; and as steam and its application to the varied purposes of civilized life becomes every day more apparent, a knowledge of its powers and properties is much wanted, and ought not to be neglected. I am the more desirous that instruction of this kind should be imparted to the rising generation in our public schools, as it would lead to practical acquaintance with instruments and machines in daily use, and would familiarize the more intelligent classes with objects on which at the present day we almost exclusively depend for the comforts and enjoyments of life. I do not mean that we should make scholars engineers; but they ought to be taught the general principles of the arts in order to appreciate their value, and to apply them to the useful purposes by which we are surrounded."

In this connection we would also call attention to certain educational views expressed by Sir John Packington, a well-known British statesman, in an address recently made before the citizens of Birmingham, on the opening of a new industrial school. The speaker urged the importance of making the study of physiology a branch of elementary education, as follows: "The study of physiology and the laws of health are now attracting to an unusual extent the attention both of the public and of the British Government. The classified records of deaths and their causes, which have of late years been kept by the Registrar-General, led to the discovery that the rate of mortality varied greatly in different localities, so much so that the deaths in some places exceeded by ten, twenty, thirty, and even forty per cent. the number in others, and it was found, on investigation, that the causes of such excess were easily removable by the application of obvious and natural means. A sanitary commission was therefore appointed to consider the application of these means, which consist of draining, ventilation, warmth, habits of cleanliness, and temperance, and so forth; and year after year the reports of this commission repeated that the application of such means was obstructed and all efforts rendered nugatory by the prevalent ignorance among all classes of the natural conditions of health,—an ignorance which prevented the advantages of sanitary measures from being either understood or appreciated. The Government was, therefore, advised to introduce physiology into the common schools of the country, and a remarkable paper was drawn up and signed by sixty-five of the leading physicians and surgeons of London, including the principal teachers of anatomy and physiology, in which are the following words: 'We are therefore of opinion that it would greatly tend to prevent sickness, and to promote soundness of body and mind, were the elements of physiology in its application to the preservation of health made a part of general education.' And here I may refer to the example of America. In no State has the educational system been more carefully or successfully matured than in Massachusetts, and among the general laws of public instruction passed by the Legislature of that State is an 'Act requiring physiology to be taught in the public schools.' The Committee of Council on Education in Great Britian have coöperated with the Board of Trade in the endeavor to introduce physiology into our schools, and a system of instruction has been devised, which has been described by high authority as 'sound and scientific in its basis and character, although limited in extent and popular in expression.' Now if a better knowledge of the laws of health is desirable for all classes, surely it is most desirable for those who are engaged in manufactures and occupations which are too likely to affect health injuriously. If health is essential to the happiness and enjoyment of all men, how much is the importance of that blessing increased in the case of the man who is dependent, not only for enjoyment and happiness, but for the maintenance and lodging and clothing of himself and his family, upon the active and constant exercise of his bodily powers."

Among the grants of money made at the last meeting of the British Association was one of $500 to Mr. Robert Mallet, in aid of what may be called volcanic experiments. Mr. Mallet has recently made public, in two portly illustrated octavos, a report on the last great earthquake in the Neapolitan territory, and on seismology in general; and, by way of supplementing those researches, he proposes to descend into the crater of Vesuvius, and ascertain by instrumental means the temperature of the active vents, and the quantity of aqueous vapor thrown out. From the quantity of vapor it will be possible to infer the quantity of water which has infiltrated down to the focus of the volcanic action, and from this and other data conclusions may be drawn of great importance to physical science.

The great work which has been progressing for four years past, under the direction and at the expense of the Royal Society (G. B.), namely, the cataloguing of the titles of all the papers and reports published in "The Transactions and Proceedings of Scientific Societies," and in scientific periodicals from all parts of the civilized world, from 1800 to 1860, inclusive, is so nearly complete that it will probably be finished during the year 1863. The work is at present in manuscript, and sixty-two volumes are already accessible for reference in the Society's library. The titles are copied in quadruplicate. When complete, the enterprise will be as meritorious to the Royal Society as it will be useful to all engaged in scientific pursuits. Many a student wastes time and labor through ignorance of what has been already achieved in the several departments of science; and none but those who have endeavored to explore the accumulated mass of scientific periodicals can judge of the weariness and hopelessness of the search. For the sake of all concerned we hope that the Royal Society will not remit their efforts until their great catalogue shall be printed and published at a reasonable price.

An important addition to astronomical literature has been made during the past year, in the publication of a very full and detailed "Account of the Great Comet of 1858," by Prof. G. P. Bond; the whole forming Vol. iv. of the Annals of the Observatory of Harvard College. The work — a large quarto — contains fifty-one engravings, many of large size, in which the comet is represented under every aspect during the whole period of its visibility, — two hundred and seventy-five days. In twenty-two of these the comet is shown as it appeared to the naked eye, and in twenty others as observed by the telescope, the effect being assisted by the tinted paper on which the engravings are printed. Mr. Bond has, moreover, taken into his narrative the results obtained by other observers in all parts of the world, and has thus produced the most complete history of Donati's Comet that has yet been written, and, we may say, the most attractive.

The publication of a splendid work, in large folio, entitled "The Satellite," has been commenced in London, by Dr. A. D'Orsan; the chief feature of which is the photographic delineation of the moon. The whole is to be finished in twelve parts. The following are extracts from the preface: "Detail being my principal object, large photographs of various separate spots are given, in addition to those which, taken at different periods of lunation, contain at once many spots and regions, and represent them under different aspects. From the guidance and instruction these afford, together with the fact of their presenting one and the same spot under various degrees of illumination, and consequently diverse appearances, elaborate drawings, founded on many years' observations, will be given, exhibiting approximately the real outline of each respective spot. . . Those photographs of the various lunar parts that have been taken at one and the same period of lunation are also joined together, and thus correct maps are given of the several phases. . . The photographs are all on a scale never before executed, — probably never before attempted."

School maps, as commonly printed, have either so many black lines as to be scarcely legible, or so few as to afford but scanty information to the student. Nor need one wonder at this defect. The text which a map should yield is so various, — first, as to the visible nature, — the shape of country, the hills and valleys, the lakes and rivers, the woods and plains; next, as to the visible work of man, — the cities and towns, the castles and fortresses, the ports and harbors, the roads and railways and canals, the mines and quarries and sea-works; then the political facts, such as the division into states, counties, and towns,— that it is found impossible to indicate all these facts, without crowding, on a single sheet. To obviate these difficulties, Messrs. Longman & Co., the well-known London publishers, have recently brought out maps on England and Wales on a new plan; *i. e.*, that of treating each group of facts on a separate sheet. It is claimed that in this way, and in this only, the great end of clearness is attained.

The most important event in the scientific and industrial history of the past year was undoubtedly the Great International Exhibition of the Industry of all Nations, which continued open in London from May to November inclusive, and of the leading characteristics of which very full notices have been given elsewhere in the present volume. M. Michel Chevalier, the distinguished French political economist, in a preface to the "French Jurors' Report," considers that this and other similar international exhibitions exercise their greatest influence for good by the opportunity they afford to nations of taking reckonings of their industrial progress; and, from a comparison of the results shown in the Exhibition of 1862 with those of the French International Exhibition of 1855, and the London one of 1851, he concludes the producing powers of mankind, or, in other words, the amount of work that one man can perform in a given time, is continually on the increase. This result he attributes to improvements in and to the more extended use of machinery, driven by water and steam power; and he gives some interesting illustrations confirmatory of his conclusion. Thus, in the manufacture of iron, M. Chevalier finds that the productive power of man has increased in six centuries to so great an extent that a man can now produce six hundred tons of iron in the same time as was required to produce one ton six hundred years ago. Again, in the production of cotton yarn, dating from 1769, when Arkwright took out his first patent, one man can now spin 400 times more yarn than the best spinner of that period. In grinding grain and making flour one man can do 150 times more work than he could perform one century ago; and in the manufacture of lace one woman can produce as much work in a day as one hundred women could execute a hundred years ago. In the refining of sugar, the whole of the operations last only as many days as it required months about thirty years since. The manufacture of looking-glasses with an amalgam of mercury and tin once occupied six weeks in fixing the amalgam on a large glass; the present process occupies only forty minutes. The engines of a first-class iron-clad frigate perform as much work in twenty-four hours as 42,000 horses.

The *recent* progress made in the working of iron and steel, as shown in the recent International Exhibitions, is so wonderful as also to deserve notice. In the London Exhibition of 1851, the largest mass of rolled iron exhibited was a round bar or roll, weighing a ton and a half; and this was regarded as something extraordinary and deserving of special mention. At the Exhibition of 1862, rolled-iron armor-plates were shown, exceeding thirteen tons in weight. In the Exhibition of 1851, M. Krupp, the celebrated steel manufacturer of

Germany, exhibited a small steel cannon as the most notable achievement hitherto effected in this branch of metallurgy. Four years subsequently, in 1855, M. Krupp sent to the Paris Exhibition a steel ingot that weighed five and one-half tons; while to the one held last year in London he sent a crank axle that weighed no less than twenty tons.

Some extracts gleaned from a recent report by Mr. Fairbairn, the eminent English engineer, on the steam "Machinery of the London Exhibition of 1862," will also be found interesting in this connection. Mr. Fairbairn states "that in 1859 the steam engines employed in the various factories, steamships, and locomotives of Great Britain amounted to 10,950,000 horse power, but that at the present time this sum has increased to 12,000,000 horse power, and this may be taken as the steam motive force in the British Islands."

Mr. Fairbairn further goes on to say, "that nearly all engines at the present time work the steam expansively; that is to say, they are so arranged in the construction of the valve motions as to cut off the communication with the boiler at one-third, one-half, or two-thirds of the stroke, as the case may be, in regard to pressure, or the power to overcome the resistance of the load. Some engineers go so far as to cut off the steam at one-sixth and one-eighth, and expand the remaining five-sixths or seven-eighths of the stroke. Formerly the principle of expansive working was very imperfectly developed; but that system is now thoroughly understood, and is in almost every case resorted to. The result of its introduction has been an immense economy; for the quantity of work now done with the same quantity of fuel is more than double what was formerly accomplished on the old non-expansive principle. It must, however, be borne in mind that this cannot be effected without an increase of the pressure of steam, and hence follows the necessity of having the boilers of increased strength and improved construction. The neglect of these precautions has resulted in serious and fatal accidents, attended with a considerable loss of life and property. Irrespective of increased pressure, and working the steam expansively, the speed of the engine has been increased about one-third since the days of Watt. In his time the piston of the stationary engine travelled at the rate of two hundred and forty feet per minute; now it averages from 300 to 320 feet; and this, combined with high-pressure steam worked expansively, increases the power of the engine, in some cases, upwards of two-fold, and, as already stated, doubles the quantity of work done with the same quantity of fuel. Thus an important saving is effected to this and every other country where steam is employed as an agent of power and motive force.

"We may further observe," continues Mr. F., "that we are far from arriving at that point of economy in the use of steam which an increased pressure and a still greater expansion is calculated to attain. It is true that the danger of explosion may be increased, and so it would be with our present means; but in our locomotive engines we already work steam at 200 pounds pressure on the square inch with greater safety than is done in our stationary engines at a reduced pressure; it is, therefore, evident that we are behind in this department, and a wide field is still open for improvement. It is not our province to point out how this can be accomplished, but we may safely affirm that the improvements already attained are only the precursors of others of much greater importance in the economy and use of steam."

The interruption of the accustomed supply of cotton during the last two years has awakened renewed attention throughout the civilized world to the subject of procuring new or substitute fibres for cotton, and many fresh projects have been started and old ones revived. Thus far, however, little or no success has attended these efforts, and it is a noticeable fact that the "trade" everywhere do not believe in them. Still, there are many who, after living to see the inventions of the last thirty years, have vague impressions that something may come of the many attempts made to find a substitute for the cotton fibre. Some are even sanguine of such a result. "Fabrics may be produced," they say, "which are not identical with cotton, but which it is not improbable may be cheap enough, and of good quality enough, to enter into competition with cotton goods." We propose briefly to discuss this important subject, and to indicate to our readers the present state of our knowledge concerning it.

New Fibres Proposed. — During the past year considerable attention has been given in Great Britain to a proposal to extract a fibre from an abundant marine plant, known as the "*Zostera marina*," or "grass-wrack." The plant takes its name from the Greek word *zoster*, signifying a ribbon, from the shape of the leaves, which resemble a long, narrow tape, and often reach a length of from three to four feet. In the British Islands it is used as a common material for packing, and by poor persons for stuffing beds and cushions. It has also been included in several patents for paper-making. Fibres extracted from it were exhibited at the last meeting of the British Association, and their value advocated; but the general opinion seemed to be that they could not be produced in any quantity, and were too weak and brittle to allow of any extensive practical application.

Fibre from Corn or Maize Leaves and Husks. — Considerable attention has recently been given in Austria to the extraction of a fibre from the leaves and husks of the maize, or corn plant, and specimens of paper and cloth have been distributed throughout the United States by the Patent Office, with an explanatory pamphlet, showing what can be produced from the above material. The cloth, or woven fibre thus made, is simply a curiosity, and of not the slightest practical value; but the paper has merit. This last achievement, however, is nothing new, as the practicability of making good paper from the leaves and husks of the Indian corn was demonstrated in the United States more than a quarter of a century ago. But the difficulty of making corn leaves and many other similar kinds of fibre-yielding substances practically available for paper-stock is, first, that the percentage of fibre contained in them is comparatively small; and, second, that the labor required to collect and prepare them can be more profitably given to other departments of business.

Straw. — For many years the attempt has been made to render the fibre contained in straw *profitably* available for the production of white paper, but with indifferent success, until within the last year, when the problem has been solved beyond a doubt. This realization of the desired end is effected by boiling the straw in an alkaline lye, in a rotary boiler, under a steam pressure of from one hundred to one hundred and forty pounds per square inch. Under such a pressure and temperature, the silica and other constituents of the straw, which render its fibre brittle and difficult to bleach, entirely give way, and separate to such an extent that they can be almost entirely removed by simple washing, leaving its fibre soft and in a condition to bleach most readily and economically. We regard this discovery as one of the most important made during the present century, and as certain to reduce ultimately the price of paper to a lower rate than has heretofore prevailed.

Jute. — The cheapness and abundance of this fibre has of late years attracted much attention, and its employment in the manufacture of textile products, especially in Great Britain, has largely increased. At the Great (London) Exhibition, as has been elsewhere noticed, Brussels carpets and rugs were exhibited, of great beauty and softness, which were manufactured almost entirely of this fibre. It is also used to form the warps of cheap broadcloths, and to some extent for mixing with silk, for which last purpose the lustre of jute is a great advantage. The chief seat of the manufacture of jute into fine goods is Dundee, in Scotland, and the quantity annually consumed there is said to exceed 40,000 tons. As the source of supply of jute, viz., India, is said to be inexhaustible, every new use that it can be put to positively increases the world's textile resources.

Flax and Flax Cotton. — Flax, for the last few years, has been an anomaly in political economy, and an exception to the generally-received laws of supply and demand. Notwithstanding a continually augmenting price, and the efforts of governments, societies, and public-spirited individuals to stimulate its cultivation by premiums, the European production of flax (and we think we may also say the American) remains stationary, if it does not decrease. The reasons for this state of things are probably these: —

First; Flax is a troublesome and vexations crop to raise. The time which elapses between the sowing of the seed and the sale of the product — if that product be fibre — is longer than is required for any other crop. The plant cannot be made to yield profitably both seed and fibre. If the seed is allowed to ripen, the fibre becomes impaired. If the fibre is the main object to be attended to, the crop must be gathered before the seed is matured. Europe sows her flax fields to-day, to a great degree, with American seed, obtained from plants which yielded little or no fibre. Flax is to the soil one of the most exhausting crops that can be cultivated. If fibre of fine quality and high price is desired, the crop must be carefully weeded and thinned out by hand labor, — a work tedious, and in America expensive.

Secondly; Although the demand for flax is great and constant, it is not a demand for the raw, agricultural product, *i. e.*, the stalk, but for a manufactured material, *i. e.*, the dressed fibre. Thus the farmer who raises, must, to sell, become to a certain extent a manufacturer. The first operation in this manufacturing process, that of "retting," or "rotting," is objectionable. It is a process of slow vegetable decomposition; unhealthy, and tending to produce malaria, especially where the result is effected by steeping the flax in pools or ponds of water. But some may say that these old processes have been obviated by new methods involving the use of steam, hot water, or chemical agents. This is a mistake. We state, on the authority of one of the leading scientific journals of Great Britain, that all the recent European experimentation on the subject has resulted in failure, and that there is everywhere a general return to the old process of "dew" and "water retting."

But the *retting*, however conducted, still leaves a sufficient quantity of gum in the straw to render the removal of the woody part, or *boon*, without injury to the fibre, a rather difficult process. No mechanical invention has yet been devised to effect this result, without occasioning great waste of fibre. Machines working economically and rapidly, as compared with the old hand-break and "skutch," or "swingle," have been invented in great number and variety; but no one of them has come into general, or even extensive use. The main reason of this probably is, that the machines are too expensive for individual agriculturists, who make flax-culture but one of a diversity of employments; and in this country flax is cultivated too sparsely to afford *much* encouragement to individuals to make its cleansing by power machinery a specialty.

In 1850, Chevalier Claussen brought prominently before the British public the project of mechanically breaking up the long fibres of flax into short fibres resembling cotton in their length; of preparing them for spinning by the use of cotton-carding machinery, in the place of the more imperfect "heckle," and of subsequently spinning them on cotton machinery, in place of employing the slower and more difficult to manage flax machinery. The objects sought thereby to be attained were an economy of time and labor in spinning flax, and of making the inferior part of the fibre, denominated "tow," equally serviceable and valuable as the longer and straightened fibres. The project seemed feasible, and British manufacturers embarked in it with great zeal and energy; but, after expending large sums of money in experimentation, the scheme was entirely abandoned. In the United States, the flax-cotton scheme from the first found many supporters, and in various parts of the country efforts were made to produce and manufacture it. In New England, the project was taken up under the auspices of one of her largest manufacturing companies, and an extensive series of experiments were conducted by the best mechanical and chemical talent available. The conclusion arrived at was substantially the same as that of the British manufacturers above referred to, viz., that the scheme, although practicable, was not profitable. The same conclusion was arrived at by other parties in the United States, who at that time tested the plan on a more limited scale, and we think we are warranted in saying that no one of the American experimenters attained a measure of success sufficient to warrant their continuance in the business. We know, at least, that no one of the many premiums offered by mechanical and agricultural societies in this country for the production of flax-cotton of good quality, in considerable quantity, has ever been claimed or awarded. Yet, notwithstanding these results, the feasibility of manufacturing flax-cotton is still maintained by many, and at the last session of Congress (1863), a bill was introduced, appropriating $25,000 to aid in the discovery of a method whereby flax-cotton could be spun on cotton machinery, — an achievement which was successfully effected more than ten years since, both in England and in this country.

The reasons which render the flax-cotton scheme economically impracticable may be briefly stated as follows: There are no inherent difficulties — mechanical or chemical — in "cottonizing" flax, or in subsequently carding and spinning the product on cotton machinery. It is impossible, however, to impart to flax a definite and uniform staple, in consequence of which it is difficult to spin from flax-cotton, on cotton machinery, a thread at all comparable with cotton in fineness, evenness, or strength. The product, therefore, is necessarily a coarse, inferior article, possessing neither the qualities of cotton or linen. But, furthermore, the whole scheme of flax-cotton, especially in this country, rests upon a supposition that there is a great amount of flax fibre which cannot be profitably worked up by any other method. This is an error. In Europe, where the legitimate flax machinery has been carried to a high degree of perfection, every part of the tow, or refuse fibre, is now made available for the production of the coarser linens, and these goods will always command better prices than anything which can be made out of the same raw material by cottonizing it. When the world is prepared to use gold in the place of silver, on the ground of economy, flax-cotton may prove a success. What is now needed in the United States is a stimulant to the more extensive growth of flax, and the discovery of cheap, effectual, and expeditious methods of extracting and dressing the fibre. America does not at the present time raise flax enough to supply the demand of her manufactories of shoe-thread and twine, and European manufacturers find difficulty in obtaining flax sufficient to supply the demand for legitimate linen fabrics. Until this end is attained to, it is idle to talk of diverting a material, of which the supply is limited, into new channels of industry. What is now needed is not further encouragement to experiments on flax-cotton, but the dissemination of correct information of what has been accomplished, and the results of European and American experience. Until this is done, our inventors and manufacturers work in the dark, and essay over and over again processes which others have previously tested.

Sewage. — The subject of the utilization of the sewage of large cities has, it is well known, been one of great interest with agriculturists and social economists for some years past. During the session of the British Parliament in 1862, the House of Commons appointed a select committee to consider and report on the subject. This committee, ably constituted, and assisted by the best scientific counsel, have, after six months' investigation, recently reported "that they have been unable to arrive at any definite or satisfactory opinion respecting the matter entrusted to them."

Specialties of Recent Scientific Progress.—In the departments of Mechanics, Physics, and Chemistry, while there has been continuous and important progress, no achievement has been made during the past year worthy of special notice. As regards projectiles and armor-plates, continued experimentation and actual war service have, as yet, led to no universally-accepted conclusions. The problem of photographing in natural colors seems fast approaching a solution, and awaits but the discovery of a method to render the colors permanent, to be, even now, a success. The spectroscope, with varied improvements, has already become a familiar instrument with chemists, and during the past year has given us some most interesting and positive additions to our knowledge of the fixed stars; so that it is not too much to expect that soon these almost inconceivably remote bodies may severally be made to describe, in the rays of light they flash to us, the nature of their elementary structure, and their chemical relations to the world we inhabit.

Liquid Diffusion.— Some important practical applications have also been made of Dr. Graham's researches on "Liquid Diffusion," and the Council of the Royal Society, England, in awarding to him the Copeley Medal for 1862, intimate that since Davy startled the scientific world by his discovery of the metallic bases, no scientific researches have been published which are so pregnant with important results.

Astronomy.—The record of the progress of Astronomical Science, during the past year, is a brilliant one, and includes the discovery of four new asteroids, four new comets, and a companion or satellite to Sirius. The number of stars known to be variable in brightness has also been increased, and one such star has been found among those visible to the naked eye. More interesting still is the discovery of the existence of variable nebulæ,—phenomena which seem even more unaccountable than that of the variable stars. The regular periodical return of Encke's Comet also took place in the beginning of the year 1862, and when first observed varied only about a minute and a half from its predicted or theoretical place,—a quantity equal to about one-twentieth of the apparent diameter of the sun,—and this when it had not been visible for three years. Our readers can infer from this statement how exact a knowledge of the movements of cometary bodies has been attained to, through the accepted theory of gravitation.

Another important event of the year is the publication of another part of the "Durchemisterung" of Professor Argelander, Director of the Observatory at Bonn. The completion of this gigantic work involves the observing and mapping of all the stars of the northern heavens, as far as the ninth magnitude, which embraces stars twenty times as faint as any visible to the naked eye. In the present portion of the work we have the places of 105,075 stars charted with so great accuracy that a good instrument and careful observing would be necessary to detect any error in the positions given. Mr. Pogson, Director of the Observatory at Madras, intends, it is understood, to complete this work by charting the southern heavens, — thus making, it would seem, almost all that could be desired in the way of celestial maps.

The government of Ecuador, S. A., has recently made a proposition to the French government to erect an observatory on the Plateau of Durito, the situation offering advantages such as few other spots in the world possess. Not only is the position of the Plateau towards the axis of the earth, and consequently towards the starry firmament, peculiarly favorable, but its atmosphere is always clear, and it is almost entirely free from the rising and falling currents of air, which offer such great optical difficulties to observation on most of the elevated points of the globe.

We present to the readers of the *Annual of Scientific Discovery* for 1863 the portrait of J. Ericsson (from a photograph by Fredericks, of New York), the inventor of the "Caloric Engine," the designer of the "Monitor" iron-clads, and the foremost of American mechanical engineers.

THE

ANNUAL OF SCIENTIFIC DISCOVERY.

MECHANICS AND USEFUL ARTS.

THE GREAT INTERNATIONAL EXHIBITION OF 1862, AND ITS NOVELTIES.

The second great English Exhibition of the Industry of all Nations opened at London, May 1st, 1862, and continued for six months; the average daily attendance of visitors being about 40,000.

In the *Annual of Scientific Discovery* for 1862, the building erected for the purposes of this Exhibition was fully described, and no recapitulation is here necessary, further than to state that the area of ground covered by the Exhibition edifice was 26 acres, with a flooring space of more than 1,500,000 square feet; while the Exhibition building of 1851 covered but 23 acres, and had a flooring space less than a million of feet.

Taking the Exhibition as a whole, no *new* invention or discovery of any *very great* value or interest was brought forward; but as an exhibition illustrative of the present state of the useful and fine arts, or of the progress which man has made in rendering natural products subservient to his necessities or his pleasures, it was magnificent and wonderful, — far beyond anything of a similar character which the world has hitherto witnessed.

From notes taken and material gathered during a careful personal inspection and study of the Exhibition, the Editor has prepared the following summary of matters which have seemed to him most worthy the attention of his readers.

Machinery. — In machinery, it was the judgment of the jury on mechanical inventions that no construction involving any strikingly new thought was exhibited. Mr. Fairbairn, in his address before the Section of Mechanical Science of the British Association, 1862, stated that the most noticeable feature of the department of mechanical inventions in the Exhibition was, in his judgment, "that the machines were more compact and better constructed than at any previous period." "I do not believe," continues Mr. F., furthermore, "that at any former period there has been such an exhibition of machines and of tools which are the creators and makers of the machines themselves. Some of the tools, such as the turning, boring, planing, and slotting machines, are of a very high order, and the tool machinery for the manufacture of fire-arms, shells, rockets, etc., is of such a character as to render the whole operations, however minute, perfectly automaton, or self-acting, with an accuracy of repetition that leaves the article when finished identical with every other article from the same machine. Such, in fact, is the perfection of the tool system as it now exists that in almost every case we may calculate on a degree of exactitude that admits of no deviation beyond a thousandth part of an inch." Mr. Fairbairn also calls attention to the evidence afforded by the Exhibition of the growing importance of the *horizontal steam-engine* in preference to the beam or vertical engine. To the horizontal system may be applied economy in the first cost, and nearly equal efficiency in its application to mills and for manufacturing purposes. Another important feature in these engines is their smooth and noiseless motion, their compact form, and the facility with which they can be applied as helps or assistants to those of larger dimensions. They are, moreover, executed with a degree of finish and accuracy of workmanship which cannot easily be surpassed.

Two facts could hardly fail of impressing themselves forcibly upon the American visitor to the machinery department of the Exhibition. The first of these was, the air of substantiability, if we may so express ourselves, or the capacity for hard service and endurance, which particularly characterizes an English machine. American machines built in England are almost invariably better pieces of workmanship than their originals; and an English mechanic seems never to use a piece of wood in mechanical construction if he can make iron available for the same purpose. This course of procedure necessarily renders the first cost of an English machine much greater than an American, but the former, from increased durability, is probably cheaper in the end, while the work produced by it, from increased steadiness, is often superior. These facts were strikingly illustrated in the locomotive constructions shown in the Exhibition. The engines forwarded by the best makers of France and Germany were splendid specimens of mechanical art, and, viewed superficially, caused the English locomotives, which stood in juxtaposition, to appear dwarfed and inferior. A closer inspection, however, showed that the English engines far surpassed the continental in the following important respects, viz., greater simplicity of design, greater compactness of form, and clearer conceptions in working out the details of the parts; "and these operations," to use the language of Mr. Fairbairn, "when carefully executed to standard gauges, render each part of an engine a fac-simile of its fellow, and hence follows the perfection of a system where every part is a repetition of a whole series of parts; and this, so far as accuracy is concerned, is a great improvement on any former system of construction."

The other fact to which we have alluded, as likely to have impressed an American visitor to the Exhibition, was the barefacedness and boldness with which machines invented, and even long used in the United States, were brought forward and exhibited as of English origin; and for which, moreover, prizes and testimonials were sought, and not unfrequently obtained. As mere assertion, however, upon a question like this amounts to but little, we would refer specifically, for illustration and proof, to the English wood-working machinery of the Exhibition; in which department we unhesitatingly assert there was not a single machine prominently exhibited which was not well known and in use in the United States for five, ten, fifteen, and even twenty years (in one instance) previously. And yet these machines — for want of any placard, or of any information in the catalogue to the contrary — passed for English inventions, and, in some, bore tickets stating that medals had been awarded to their exhibitors. As another illustration bearing more specifically upon this question, we would call attention to the fact that the machine for folding books and newspapers, which was invented, patented, and came into use in the United States previous to 1850, was exhibited the past season in London as a new and original foreign invention, and as such was described, figured, and recommended in leading English journals. Again, the prize-medal threshing machine in the French department was of acknowledged American origin; a handsomely constructed corn-sheller from Tuscany, the best finished implement shown of Italian construction, was an exact copy of a machine in use in the United States years ago; while in the Prussian department was shown a Wood's reaper, the exact counterpart of which was, at the same moment, on exhibition in the United States department. We are well aware that facts like these will have little of novelty to many American mechanics and engineers; yet the evidences in the present instances were so pertinent that we could hardly refrain from alluding to them thus publicly.

Marine Engines. — With respect to the comparative character of the marine engines in the Exhibition, the London *Engineer* says: — "The triumph of the screw over the paddle is complete. All the engines are direct acting, and the stroke in the largest does not exceed four feet. No new style of engine has been brought forward, but the mechanical skill exhibited in the construction of all receives high praise. The screws for the French engines have edges as sharp as a lady's fan, while the British screws are rounded off at the corners. There can be no question of the fact that by rounding the edges of a screw propeller its useful effect is increased so much as to give an additional speed of from about eleven to twenty-five per cent. to the vessel. One thing very striking and dissimilar between screw and paddle-wheel engines is the very short stroke of the former compared with that of the latter. For example, the new paddle-wheel steamer *Scotia*, of the Cunard line, has cylinders of one hundred inches in diameter and twelve-foot stroke, while the *Achilles*, a new gigantic British war screw-steamer, has cylinders one hundred and twelve inches in diameter, and only four-foot stroke."

Disc-Propeller. — A model, bearing this name, was exhibited by the inventor, Mr. Ashton, to illustrate a new method of propulsion. It was simply a common paddle-wheel with the floats removed; or, to give a more familiar idea of the invention, three penny pieces, mounted on an axis, with a little distance between them, form, to all intents and purposes, the disc-propeller. It seems strange that a paddle-wheel without paddles should be able to propel at all; but Mr. Ashton has proved that not only does it propel, but that it propels nearly, if not altogether, as quickly as if floats were attached. It was claimed, moreover, to be much more economical than a paddle, driving, with a given speed, the vessel with a smaller consumption of coal; producing no vibration; and, what is of no small importance in canal navigation, not the slightest swell.

Iron Fabrication. — In illustrations of iron fabrications the Exhibition was exceedingly rich. The Butterley Iron Company, of England, exhibited a rolled boiler-plate twelve feet nine inches long, seven feet six inches wide, and one and a half inch thick. Krupp, the celebrated steel manufacturer, of Essen, Germany, has recently proposed to construct rolls not less than seventeen feet in width, and to manufacture therewith a boiler-plate sufficiently large to form of itself an entire boiler; and from the great success which Mr. Krupp has already achieved in working iron, there can be little doubt but that he will eventually accomplish his object.

Of *sheet-iron* there were numerous fine illustrations. Fine sheets from Belgium were especially characterized by a smooth and dark-bluish-gray, glossy surface. The color here was obviously due to a thin and firmly adherent skin of oxide of iron, which has been detached here and there near the edges of several of the sheets, clearly revealing the color of the subjacent iron. The London *Times*, in noticing these specimens, stated that they could not as yet be produced in England. Russia, however, still continues without a competitor in the production of a peculiar description of sheet-iron, which has long been highly esteemed in commerce. The quality of the iron, which is both smelted and worked with charcoal throughout, is excellent, and the dark polish on the surface is remarkable. The process of manufacture is not known, and mythical stories are current as to the precautions taken with a view to secrecy, and the lamentable fate of those who have gained unlawful access to the works in order to possess themselves of the mystery. The manufacture of this description of sheet-iron in other parts of the world is a great desideratum, and the man who succeeds in introducing it will probably not have cause to repent. The Russians are said to anneal their sheets with charcoal-dust interposed, and finally to hammer them in packets. They are not all obtained equally good, and a selection is accordingly made.

No metallurgical illustrations in the Exhibition were more interesting at the present time than the rolled armor-plates for ships. We give the dimensions of two manufactured by the Atlas Works of Sheffield: — (No. 1.) Length 21 feet 8 inches, width 4 feet 2 inches, thickness 6½ inches, weight 10 tons 12 cwt. (No. 2.) Length 24 feet, width 3 feet 8 inches, thickness 5 inches, weight 7 tons 17 cwt. A few years ago the rolling of such enormous masses of iron would have seemed incredible. In the Great Exhibition of 1851, Messrs. Bagnall, of South Staffordshire, England, presented a rolled round bar, which was considered extraordinary on account of its size, but it weighed only $1\frac{1}{4}$ ton. In the Paris Exhibition, in 1855, there were much larger bars, but still nothing that could compare in weight with the gigantic bars above mentioned. As the public mind is at the present time so much interested in everything relating to armor-plates, we present a description of the process by which the two great plates above referred to were manufactured. The metal consisted of "best new scrap," obtained from a mixture of Swedish, Shropshire, and Derbyshire refined iron. It was balled under a four-ton steam hammer, piled under a six-ton, and rolled into bar, re-rolled into slabs, all crossed, then rolled into "moulds," and lastly rolled into the finished plates. There were 360 layers in the $6\frac{1}{2}$-inch plate. The expense of manipulating such enormous masses of iron as these armor-plates is necessarily very great; and the present cost of them ranges between $175 and $225 per ton. The display of bars, rails, and girders, in the Exhibition, was very fine and extensive; and in no branch of iron fabrication has greater progress been made within the last few years. The mill-power required to produce some of these articles must be enormous, but we are probably far from having reached the *maximum* limit. Among the curiosities in this department — shown, probably, as evidences of what could be done — were a rail 117 feet long and $5\frac{1}{4}$ inches deep, and a tension bar for girders 83 feet long, 1 foot wide, and 1 inch thick; both sent by the Butterley (English) Company. Another company exhibited two rails of the following dimensions: — One 53 feet 6 inches long, $4\frac{3}{4}$ inches across the head, and 10 inches deep; the other 31 feet 6 inches long, $5\frac{1}{2}$ inches across the head, and 15 inches deep. The Austrian Society of State Railways exhibited specimens of rails, some with the head of granular and the foot of fibrous iron, and others of puddled steel. This is a great manufacturing company, established in 1855, with the view of producing everything required for the use of railways. They not only smelt and manufacture iron, but meddle with copper, lead, gold, silver, paraffine, etc. How far this system is founded on correct economical principles the future will decide.

A collection of architectural irons from France indicated, what is generally believed to be the fact, that iron is much more extensively used in that country for building purposes than in England. Of *forged iron*, two objects were preëminently worthy of notice, both by the Mersey Steel and Iron Company, of England. One of these was a monster engine-shaft, weighing about twenty-five tons; the other was an armor-plate bearing the following inscription: — "This armor-plate, 21 feet 3 inches long, 6 feet 3 inches wide, $5\frac{1}{2}$ inches thick, having a superficial area of 133 feet, weighing upwards of 13 tons, was forged at the Mersey Steel and Iron Works, Liverpool, and has been neither smithed nor tooled since it left the steam-hammer. This plate would have been made 15 feet to 20 feet longer if space could have been obtained." The same company also exhibited a monster wrought-iron muzzle-loading gun, called the Prince Alfred, and forged hollow by a process patented by the superintendent of the works, Mr. W. Clay. This gun is 12 feet long, 35 inches in diameter at the breech, 18 inches at the muzzle, $10\frac{1}{4}$-inch bore, and weighs 10 tons. The rifling consists of twelve shallow grooves, making one turn in 30 feet. Before being rifled it was fired with a 140-pound ball, and 30 pounds of powder, against a target of 4½-inch iron plates, backed with timber and sand. The plate was indented six inches, but not actually penetrated, and was exhibited along with the gun. During the process of forging it was necessary to move these heavy masses with ease and rapidity, just as a blacksmith handles his iron; and, in order to effect this, most powerful mechanical appliances and the exercise of great skill must have been indispensable.

The Exhibition contained many very interesting illustrations of *welding* under difficult conditions, and of these we will notice a few, without attempting, for want of space, any description of the processes employed. The Butterley Company, above referred to, showed a girder in the form of a double T, twelve inches across each end, and three feet deep, welded longitudinally. A large, stamped, solid wrought-iron wheel was shown in the English department, as an example of combined strength and cheapness. Illustrations of the successful welding of iron and steel in railway tire bars were shown by the Monkbridge (English) Company. In these the melted steel was cast round an iron tire, the latter being first heated to redness and dusted over with borax powder. The union of the two metals in the specimens exhibited seemed perfect, and even where the combination was hammered out into thin plate there was no sign of any separation. This process is the invention of a Frenchman, and promises to be very valuable. The French, indeed, have recently made such progress in the manufacture of iron, that bars of beam-iron are now constantly exported to England from France as an article of commerce. Another curious fact, bearing upon the vexed questions of tariff and free-trade, brought out during the past summer in a published correspondence in the London *Times*, was, that Belgium, which for years past (and at the present time) has maintained a prohibitory duty on the importation of foreign iron, not only undersells British rolled and bar iron in foreign markets, but even largely exports the same products into Great Britain.

Among the curiosities in this department were two bars of malleable iron: one, which had been tested by the admiralty to 64 tons per square inch, the standard strain being 59 tons, and which broke the admiralty chains instead of yielding; the second, which had been tested with a strain of 51½ tons, by Mr. W. Fairbairn. There were also several pieces of crystalline iron, polished like silver, and suspended by silken cords, which, when struck, emit a note as clear as a bell, showing the perfect homogeneous character of the metal.

Chain Cables. — The prize medal for the best chain cable was awarded for a patent plan invented by Sisco and Sinibaldi. The links of this chain are oval in shape, made from hoop iron, galvanized and brazed. The hoop is wound on a reel by a machine, the invention of the patentees, till the thickness required is secured. It is then passed through a furnace of molten metal, and afterwards rounded off for the completion of the latter operation of brazing. Between the links there is a stay as in the ordinary chains. The principle may be understood by taking a long slip of paper, or tape, and rolling it round the hand, lay upon lay, till the necessary thickness of a chain is gained, then placing a stay across the inner part of the oval thus formed, and a good idea is obtained of Sisco and Sinibaldi's rolled hoop link. The advantages of this make are the doing away with welding, and increased strength. In a common chain one bad link destroys the security on which a ship is held, and unless a chain is severely tested, a flaw or imperfect weld may send a vessel and crew to destruction. Sisco and Sinibaldi overcome this defect in welding, which makes the iron brittle, by making rolled hoops homogeneous. They coil the hoops cold, and the dipping the chain into molten metal, by heating every part equally, consolidates the layers into one mass, and constitutes a really strong chain. In rolling hoop iron in this manner, there is danger of fracture at the bend; but where there are so many consecutive layers, the fracture of one is of no serious consequence, for its weakness is counteracted by the liquid metal which enters and brazes it to the hoops on either side. The strength of this hoop chain must be comparatively great, for every layer has a skin, and each link is made of sixteen layers, so that the chain is never likely to snap. If one skin is broken, the other fifteen may be intact, and the breakage of one skin will give warning to the crew, whereas, by the existing chain, there is no premonition, and the snapping is sudden. In this respect the patented chain of Sisco and Sinibaldi partakes of the character of a rope, whose strands give before it breaks. The links of a good iron cable will be elongated before it parts, but bad iron snaps without distending. The admiralty strain for a 2-inch chain is 72 tons. A chain this same size, made from rolled hoop iron, was tested at her Majesty's yard at Woolwich. It was attached to a testing chain of $2\frac{1}{2}$ inches in diameter, and on the hydraulic power being applied, one of the links was lengthened $\frac{5}{8}$ of an inch, and the other $\frac{1}{8}$ of an inch, when it reached a strain of 110 tons; and the $2\frac{1}{2}$ inch testing chain broke off in two places when the strain reached 114 tons. The hoop iron chain had some openings in one of the links, which had been imperfectly brazed, but it did not appear to have been made otherwise defective. One link of the same dimensions, 2 inches thick and 2 inches broad, was afterward placed in the testing frame, and when a strain of 70 tons was applied it had lengthened $\frac{1}{12}$ of an inch; with 80 tons, $\frac{1}{8}$ of an inch; with 100 tons, $\frac{3}{16}$ of an inch; with 110 tons, $\frac{1}{4}$ of an inch; with 115 tons, $\frac{5}{16}$ of an inch, and when it reached 120 tons' strain it was considered advisable not to continue the strain, as it was so great as to loosen the stone frame on which the machine rested, and liable to damage other parts of the iron frame of the machine. The strain applied on this occasion was one ton more than had ever been previously applied, and the hoop chain was only slightly opened on one side.

Steel Manufacture.—Never before has so complete, and, in some respects, so marvellous a series of specimens illustrating the manufacture of steel been witnessed as was shown in the Exhibition building. In order to make clear to the general reader the nature of the various steels here brought together, we propose to state first, as concisely as possible, the properties of steel; and, secondly, to explain the principles of the various processes by which it is made. In the first place, then, steel may be said to be, essentially, iron containing carbon within certain limits, which cannot be exactly assigned, but which may be taken, approximately, as a half to one-and-a-half per cent. Steel is much more fusible than wrought iron, and may be melted in ordinary furnaces, when it is termed cast steel. Steel may be welded to steel, or to wrought iron, under suitable conditions as to quality of metal and temperature. The fracture of steel is peculiar, and varies with the proportion of carbon and the treatment which the metal may have previously received. It is more or less finely granular, and when produced in the brittle state of the metal may be conchoidal or shell-like, such as is presented by the broken surface of a lump of glass.

The processes now in operation for producing steel are founded on two opposite principles, namely, putting carbon into wrought iron, and taking carbon out of pig iron, which last, it will be borne in mind, contains more carbon than steel.

Carbon is put into iron in the following ways: 1. By melting wrought iron with carbon. This is the ancient Hindoo method of preparing the famous "wootz." The principle has recently been revived in making the so-called homogeneous steel or metal. Numerous specimens of wootz, sent from India, were exhibited in the Exhibition, in the form of little conical ingots; but there was nothing peculiar about them to demand special notice. Not so with regard to the so-called homogeneous metal, which has excited much attention of late. It is extremely malleable and tough, and may be placed midway between wrought iron and ordinary steel; it may be regarded as steel containing a low percentage of carbon. This is the metal of which the celebrated English engineer, Whitworth, has constructed his largest rifled ordnance. It is no doubt extremely valuable for many purposes, but it is, thus far, difficult to produce it uniform in quality. Examples of tubing made of this metal were shown, *flattened down vertically*, and at first glance might be mistaken for India-rubber. The metal, in this instance, we were informed, was produced by melting pieces of Swedish iron and carbonaceous matter. In the specification of a recent English patent granted for manufacturing homogeneous metal, it is stated that scale, which falls off from steel or iron during the process of hammering or rolling, is employed in addition to the ingredients in common use for cast steel.

2. Another process of introducing carbon into iron is known as "cementation," and consists essentially in exposing flat bars of iron imbedded in charcoal to about the temperature of melted copper during many days. Carbon thus travels into the very centre of the bars; but how this takes place has not yet been clearly explained. This process of preparing steel is an English one; the furnaces are termed "converting furnaces," and the bars of steel produced are called "blister-steel," from their being studded here and there with blister-like protuberances.

A great number of examples of steel produced by the cementation process were shown in almost every department of the Exhibition; but there was nothing about them which requires from us any particular comment. Until recently, all the steel at Sheffield, England, was made by this process, and Swedish iron has been largely consumed for the purpose. Different varieties of iron are known to yield different qualities of steel, but the knowledge respecting these differences is generally regarded as a trade secret. The prices of Swedish iron in the English market vary considerably, *i. e.*, from $160 to $60 per ton; and the iron-masters affect much secrecy, especially with each other, regarding the prices at which they dispose of their iron. In this connection it may be also stated that Sheffield no longer maintains her boasted preëminence in the manufacture of cutlery, it being generally acknowledged that the French common cutlery, such as table-knives, and also the French surgical instruments, are far superior in general to those of English workmanship.

3. A third process of putting carbon into iron consists essentially in exposing rich iron ore to the action of reducing gases, whereby the metal is obtained in a metallic and more or less spongy state, and then melting this metallic sponge, previously impregnated with carbonaceous matters. Cast steel is thus produced, and the process is known as Chenot's, from its inventor. At the time of the French Exhibition of 1855 great things were predicted of this process, and the "*grande médaille*" of honor was awarded for it; but since then it has not proved successful in a pecuniary point of view. In the Exhibition, the *eponges metalliques* were exhibited in great variety by the Brothers Chenot, of France.

Carbon is taken out of iron, 1. By exposing pig iron to the action of a blast of atmospheric air at a high temperature in a charcoal hearth. "Natural steel," as the material thus formed is termed, is largely manufactured in central Europe; the most renowned establishment being the "Imperial Works" of Styria, Austria. 2. Another method of extracting carbon from iron for the production of steel is by the process termed "*puddling*," which is so conducted as to leave sufficient carbon in the iron to produce steel. Wrought iron is obtained from pig iron by puddling, — that is, heating the metal in a reverberatory furnace with free access of air, and working it about until the carbon is burnt out, or nearly so. Now, if steel be only iron containing more carbon than wrought iron and less than cast iron, it is obvious that in puddling the intermediate state of steel must be passed through. But it is only recently that steel has been made by puddling, yet "puddled steel" is now very extensively manufactured on the continent of Europe. In Great Britian, however, it has not as yet been largely developed. Considerable skill is required in the management of the process, and under any circumstances it is difficult, not to say impossible, to produce steel of uniform quality, even in the same operation. In the Exhibition, specimens of "puddled steel" were exhibited by the Krems Ironworks, of Styria, which were produced with raw lignite as fuel, which contains twenty-five per cent. of water, and much ash. Railroad bars of puddled steel were shown from Prussia, and from Sweden puddled steel produced with wood as fuel.

3. A third process of producing steel by extracting carbon from iron is by "blowing air through melted pig iron." This is the process of Bessemer, which has excited so much attention of late, and deservedly so. The carbon and silicon are readily burnt out, and a considerable quantity of iron is also oxidized, as is the case in every process in which pig iron is converted into wrought iron. What could, at first sight, appear easier than blowing air through melted iron? An idea is one thing, and its realization in practice is another. Bessemer has had to contend with many practical difficulties, and is

entitled to great credit for the ingenuity and perseverance which he has displayed in surmounting them. This remarkable process is probably destined to effect greater changes in the manufacture of iron and steel than many of our iron-masters suspect or would be willing to believe. As a spectacle, there is nothing so startling and, in our view, so magnificent in the whole range of metallurgy. The melted pig iron is allowed to flow from an adjoining cupola furnace into the "converting vessel," which is a circular vessel of iron coated internally with a refractory lining of silica. Several jets of air are then blown in at the bottom, and bubble up through the metal. For a time all goes on quietly, but the temperature gradually increases, and at length a volcanic eruption in miniature suddenly occurs, melted scoriæ being projected on all sides with great violence, and which if allowed to escape would inflict serious mischief on any unhappy bystanders. But soon all is again tranquil, and the chamber contains malleable iron in a state of perfect liquidity. This may be tapped out into moulds, and, with special precautions, drawn out into bars, etc.; but it is apt to be cellular and unsound, effects which Mr. Bessemer has had great trouble in overcoming, if even now he has thoroughly succeeded. Steel is made by introducing into the melted iron in the converting vessel a given quantity of spiegeleisen (spathic iron ore, carbonate of iron), containing a known percentage of carbon; and so steel may be produced with any required proportion of carbon. The spiegeleisen dissolves in the iron like sugar in water, rendering the metal more fusible and very liquid. Unfortunately, in the Bessemer process, when pig iron containing phosphorus is operated on, this injurious element is not separated in a sensible degree, as is the case in the process of puddling; so that only those varieties of pig iron which are free from phosphorus, such as hæmatite pigs, etc., can be advantageously used. The Bessemer process is now carried on by three large establishments in England, two of which are in Sheffield; and that it should have succeeded in establishing itself at such a stronghold of prejudice as Sheffield augurs well for its final success. The Sheffield people, however, maintain that good steel for cutlery cannot be obtained by Bessemer's process. Specimens of Bessemer steel were also sent to the Exhibition from manufactories in France and from Sweden, in which last country it is extensively introduced. The process has not yet made its way into Austria. The Prussians have tried it, but failed, and assign as the reason the unsuitable quality of the pig iron employed. It has also been introduced with success in India, for which country it seems preëminently adapted, as suitable pig iron can be readily made there, but where, owing to the heat of the climate, it is especially desirable to avoid the laborious work of puddling. Mr. Bessemer introduced his process in 1855. It was received with approbation by some iron-masters, and with contempt by others; but it is now evident that it is destined to play an important part in the future history of metallurgy. In the Exhibition, Mr. Bessemer made a very extensive display both of iron and steel produced by his process, and of specimens illustrative of the quality of the metal, as shown by hammering, punching, bending, twisting, stamping, rolling, drawing into tube and fine wire, turning, polishing, etc. A rail was shown, eighty-four pounds to the yard, which may be supplied at £13 per ton. The tensile strength of the Bessemer steel is great, and the metal is now obtained of very uniform quality. Out of twenty-eight pieces taken at random in one establishment, the extreme of difference in tensile strength was about five pounds or so. Mr. Bessemer also exhibited a twenty-four pounder gun in the rough, and another of the same rate in the finished state. That in the rough is a solid forging of Bessemer steel, forged from an ingot eighteen inches square, and weighing twenty-eight hundred-weight. It was stated that the material of which these guns were composed possessed nearly double the strength of the best "Low-moor" iron, and that their cost was less than wrought iron in the same shape. Steel was also shown in the Exhibition produced by the so-called process of "*Uchatius*," which consists in melting together granulated pig iron and oxide of iron, when the carbon of the former is more or less burnt out at the expense of the oxygen of the latter, with a corresponding reduction of iron. The proportions should be so regulated that sufficient carbon may be left to form steel. This process, which excited much attention a few years ago, has not, as yet, come into extensive use, it is said for two reasons: First, the difficulty of obtaining uniform results; and, secondly, the high cost.

There was also shown, in the British and Swedish departments, steel produced by melting together charcoal, pig iron, and scrap wrought iron. Here the product retains the whole of the carbon, and the relative amounts of the ingredients used must be such as to produce steel. It is requisite for this purpose that the pig iron should be of good quality. The reader should bear in mind that all steel, by whatever process it may have been produced, is termed *cast steel* after having been melted. The variations in quality of the different kinds of steel in commerce are innumerable, and in many cases the reasons for such variation are quite unknown. They are undoubtedly chemical, but have hitherto baffled the efforts of chemists to detect them. Much attention has, however, of late been directed to this most interesting subject, and there is now some hope that we shall not much longer remain in our present state of ignorance concerning it.

In the Austrian department, specimens of the so-called "wolfram" steel were shown, made by melting together cast steel and the mineral wolfram, by which addition it is believed the quality is greatly improved. Steel thus produced breaks with a very fine grain, and is hard and tough; but we have learned, on excellent authority, that this alloy has not been found practically successful.

Much has been said of late respecting the value of titanium and other elements in steel; but we learn that the best practical authorities in England do not as yet consider that any satisfactory evidence of the good effects of the presence of such foreign matters in steel has been presented.

Krupp's Cast Steel.—But one of the most extraordinary and most important collections of the Exhibition, and one the like of which has never before been witnessed, was a display of cast steel made by Mr. Krupp, of Essen, Germany. The special points of interest about this manufacturer's exhibit are the wonderful soundness and the enormous size of the castings; and in these respects he is so far in advance of all other producers of cast steel that it will be extremely difficult to approach, much more to overtake him. Krupp affects considerable mystery in his processes. He rejoices in astonishing the world by the magnitude of his operations; and, like many others, who have far less reason for self-gratulation, he is not inaccessible to the charms of popular applause. He has printed a handsome series of plates of various objects of his manufacture, which is prefaced by four photographic views of his works in Essen. They are evidently of large extent, and are reported to occupy, one way or other, one hundred and eighty acres of ground. It is stated that he employs puddled steel, which is broken up, assorted, and re-melted in crucibles. This variety of steel does not appear to be adapted for cutlery. It is affirmed that there is a great consumption of plumbago and leather-parings at the Essen Works. Each crucible is said to contain seventy pounds of steel, and the furnaces in which they are heated vary much in dimensions, the smallest holding two, and the larger twenty-four crucibles. When a large casting is required, the organization has been carried to such a remarkable degree of perfection that at a given signal all the crucibles needed are ready to be taken out of the furnace at the same time. Their contents are poured with the utmost rapidity into a large reservoir, and from this the metal is cast. By this means, as in bronze-founding on the large scale, homogeneity is attained. The apparatus for working the steel is the most gigantic yet constructed. There is a steam-hammer weighing fifty tons. The anvil face weighs one hundred and eighty-five tons, and cupola furnaces were built expressly to melt this large quantity of metal. The largest casting in the world is the great bell at Moscow, reported to weigh one hundred and ninety-two tons; but it cracked in cooling, and was never removed from its birthplace. Krupp's anvil rests on eight blocks of cast iron, weighing from 125 to 135 tons each, and making a total weight of 1,250 tons of cast iron! This solid structure of iron is supported on a wooden foundation, forty feet square. The mould for casting steel solid is constructed so as to avoid the presence of all angles, of which the inevitable effect would be to cause a lodgment of the air, and consequent unsoundness due to bubbles. Vent-holes will not suffice to remedy this evil, as they become so soon stopped up by the rapid solidification of the steel that the air has not time to escape. The largest casting exhibited by Krupp, in 1851, weighed two and one-quarter tons, and the largest in the Exhibition of 1862 weighs twenty-one tons. It was in the form of a solid cylinder, about nine feet high and three feet eight inches in diameter, and was broken across to show fracture. We inspected the fractured surface over and over again, even under a good lens, and failed to detect a single flaw. The largest casting Krupp ever made weighed twenty-five tons. Now, when we reflect that this enormous mass of metal is melted in comparatively small crucibles, we get an idea of the perfect organization requisite to have every crucible ready, and the pouring effected at almost the same moment of time; and it is in this organization that we are disposed to think one great merit of Krupp consists. A large rectangular ingot, weighing fifteen tons, was also exhibited; it was broken across in eight places to show uniformity of quality and structure; was cast cylindrical, and reduced afterwards under the hammer to the rectangular shape. M. Krupp also exhibited shafts, rolls, railway tires and wheels, locomotive axles, and guns, of cast steel. The largest of these last was of nine-inch bore, and weighed nine tons, being a single mass of cast steel, and by far the largest gun of this material hitherto made. It was, however, hardly more than a steel forging, bored and rough-turned, for, although open at both ends, no breech-loading arrangement was shown, nor had the bore been rifled. Other guns of smaller dimensions were also shown in considerable number, each in the same stage of finish as the nine-inch gun.

In the vicinity of Krupp's works, at Essen, is another cast-steel establishment, known as that of "Bochum." We are informed that the processes here adopted are the same in all respects as at Krupp's, and that access to the works is liberally granted by the proprietors. A large cast-steel bell was the principal object sent from Bochum to the Exhibition.

Ordnance. — Of war implements in the Exhibition there seemed to be no end; the British government leading off in the display, and every European power following, except France and Austria, which sent nothing officially. The heavy guns exhibited by the British government were all breech-loaders, mostly of the Armstrong pattern; and this breech-loading system characterized all of the guns sent by the continental workshops except Spain, which, in common with France, has neglected it. In the Italian department specimens of the so-called Cavalli gun were shown. The inventor, Gen. Cavalli, although an advocate of the breech-loading system, does not adopt the compression system for his projectiles, which are of simple cast iron, without any attempt at the exclusion of windage. The projections, which are cast on the shot, and which fit loosely into the grooves, impart the necessary rotary motion, which, combined with the form of the projectile, the General considers to be sufficient to secure accuracy of fire and length of range. This gun, for heavy artillery, has been adopted to a considerable extent in the Italian army, but their field-artillery is rifled upon the French system of Treuille de Beaulieu. From Sweden the guns were constructed on the plan proposed by Baron Von Wahrandorff, who uses breech-loaders, with a system of lead coating, affixed mechanically to the sides of elongated projectiles, to enable him to rifle his guns on the compression principle. A gun, exhibited as the invention of Lieut. Engstrom, of the Swedish navy, was of cast iron, rifled in four grooves; the projectile was cylindro-conical, with eight wooden studs attached to it. These projectiles were tested in England some years since, and were then unfavorably reported on; but it is asserted that since then improvements have been made which obviate the defects complained of. Experiments are being carried on with this system of ordnance in France, Russia, and other countries. General Guiod, of the French artillery, asserts that in France favorable results have been obtained. In small-arms, specimens of the rifled gun, adopted in 1860, for the Swedish army, were exhibited. This rifle is sighted for ranges of 600, 1,000, 1,400, 1,800, 2,200, 2,600, and 3,000 feet, and is said to range with effect for 4,000 feet. It is manufactured at a cost of £2, all the materials being Swedish. The manufactory employs 250 workmen, and turns out 5,000 rifles annually. The Board of Ordnance of Christiana exhibited specimens of the rifled musket in use in the Norwegian army, interesting from the fact that breech-loading has been adopted throughout the army, and that the bore is hexagonal; this principle having been in use for some considerable time. Spain, like Italy, has adopted the French system of rifling in her artillery, namely, that of Treuille de Beaulieu, and sent several specimens to the Exhibition. The royal foundry of Trubia produces all the steel and iron, both wrought and cast, required for the use of the Spanish service. This foundry exhibited, as a specimen of the rifled iron ordnance now adopted in the Spanish service, a gun of cast iron, strengthened with bands of steel, and rifled after the French model, about 10 feet 9 inches in length, and weighing about 8 cwt., the diameter of the bore being 16 centimetres ($6\frac{1}{4}$ inches). The charge for this gun is $8\frac{1}{4}$ pounds, and with sixteen degrees of elevation it is stated to have attained a range of upwards of 6,000 yards with a cylindro-conical ball of 68 pounds weight. Austria, like many of the other nations of Europe, has been attracted by the advantage which the French system of rifling ordnance possesses, of enabling existing stores of artillery to be utilized, and has consequently adopted that principle since the early part of 1860. No display, however, of ordnance was made from this country. The question of the adoption of a rifled arm for the artillery of Russia is still to a certain extent undecided as regards heavy guns; but the greater proportion of their field-artillery has been rifled upon a principle which is only a slight modification of the French method. A rifled gun of cast steel, in this department, bore an inscription stating that four thousand rounds had been fired from it without injury. The Prussian government have adopted the Wahrendorff principle (above noticed), both as regards breech-loading and lead-coated projectiles.

Impregnable Port-hole. — In the naval department a model was shown for closing the aperture of a port-hole, during the time when it is unoccupied by the gun, with a revolving shield. The gun goes out through a ball, or spherical revolver. This revolver moves on axles, and allows the gun to be turned in every direction; and whichever way the gun is pointed, whether elevated, depressed, or trained aft and forward, there is no opening disclosed for the entry of a Minié bullet. When the shot is discharged, the gun recoils, and the revolver turns, and presents a closed appearance to the exterior.

Improved Furnaces. — In the Swedish department specimens of iron were exhibited made with peat as fuel; and in the Italian department steel was shown made in a gas-puddling furnace with the same fuel. The furnace in which peat is thus made available for metallurgical purposes, although not easily described without diagrams, is still so well worthy the attention of those interested in economizing fuel, that we make the attempt to render its structure intelligible to the general reader. We must assume, in the first place, that he is acquainted with the form and action of a common reverberatory furnace such as may be seen in operation in many parts of the country. Instead of the usual fire-place, there is what is called the "gas generator." This consists of a circular chamber of fire-brick several feet deep, and two or three feet in diameter, closed at the bottom, and having a hopper at the top, through which fuel is supplied. This chamber, at a certain height from the bottom, is in direct connection with the body of the furnace, so that flame may issue as freely from it as from the fire-place of an ordinary reverberatory furnace. In the sides of the generator, at a certain distance from the top, is a series of three or four small, round holes on the same level, and at some distance lower down is another similar series of round holes. These holes are for the passage of the air intended to support combustion in the interior of the generator, which is blown in either by a fan or some other convenient blowing-machine. Now, when the generator is full of incandescent fuel, and air is injected through the lateral holes, carbonic oxide gas is copiously produced and passes into the furnace, as there is no other place of egress, the hopper at the top being supposed to be shut. As it escapes from the generator, it is met with a current of heated air, or, as it is technically termed, "hot blast," which is injected downwards from the roof of the furnace at or near its junction with the generator, either in several jets or in one continuous sheet. The carbonic oxide while still hot is thus burnt; and the heat developed is sufficiently intense even to melt wrought iron by the hundred weight. The air which supplies the generator is also previously heated; and in the Swedish furnaces the apparatus for heating the blast consists of a series of cast-iron pipes fixed at the lower part of the stack. Hence only the waste heat of the furnace is employed for this purpose. It is usual to place a hollow cylinder of iron round the generator, so as to leave a closed space between its internal surface and the exterior of the generator; and into this space the hot blast is introduced, whence it passes through the two rows of holes previously described into the interior of the generator. The atmosphere of such a furnace can be rendered either reducing or oxidizing at will by regulating the amount of blast. At the bottom of the generator is a door, by means of which the ashes or clinker from the fuel may be withdrawn. These furnaces can be so modified as to suit any kind of fuel. A recent writer in the London *Times* advocates their use even for the burning of anthracite. He says, "This kind of coal gives intense local heat, but this inconvenience might easily be remedied by introducing along with the air into the generator a certain proportion of steam. This steam would be decomposed, with the formation of carbonic oxide and hydrogen gases and some carbonic acid, and a considerable reduction of temperature would be the result. But the heat thus removed from the chamber would be subsequently restored in the body of the furnace by the burning of the combustible gases derived from the decomposition of the steam, so that there would be no loss of heat, but only a transference of it from the generator, where it is not wanted, to the furnace, where it is applied. The fact is, our mineral fuel has been so abundant, and so easily accessible, that it has been most cruelly wasted. But matters are not quite so smooth as they used to be, and necessity is beginning to compel attention from our iron-masters to the subject of economizing fuel in every possible way. The old reverberatory furnace is only a clumsy sort of gas furnace; but in the Swedish peat-furnaces the fuel is converted into combustible gas, which may be applied under most advantageous conditions."

For burning fine coal we noticed a form of grate, a German contrivance, the "step-grate," formed of flat bars of iron, arranged with the wide side uppermost, one above another, and with a certain space between them. An inclined grate is thus constructed, through which not even the finest coal can drop, provided the bars are allowed sufficiently to overlap, and yet there is ample space for the admission of air. We have a conviction that these grates can be introduced with great advantage in this country, especially with a view to the utilization of fine coal refuse, and that they only require to be known to insure their immediate and extensive adoption. Such grates are in pretty extensive use in several localities on the continent of Europe, more particularly for the consumption of lignite. In the south of France grates on the ordinary principle, but composed of very narrow and deep bars much nearer together than usual, are adopted with success in the case of small coal impregnated with much iron pyrites. These bars are of cast iron, one half-inch thick at the top, and only one quarter-inch at the bottom, and five inches deep; they are placed three-eighths of an inch apart. We are informed that since this plan came into use the bars of marine boilers in some cases where the coal is bad last three times longer than previously.

Siemens's Regenerative Furnace. — This furnace, which has recently excited great attention in Europe, was exhibited in model. Its principle of construction we will endeavor to explain. Every one must have been struck with the prodigious amount of heat which escapes up the chimney, especially in furnaces where smoky flame may frequently be seen issuing from the top. One great object of Siemens is to save and transfer this heat back into the furnace; and this is done in the following manner: We assume that the reader has seen an ordinary glass-house furnace, whether for the manufacture of flint, crown, German sheet, or plate glass. Now, under or near such a furnace let there be erected four distinct fire-brick chambers, each of which may be put in connection with the interior of the furnace and the stack or chimney. Let each chamber be filled with fire-bricks, piled much in the same manner as bricks in a kiln, so that air may circulate everywhere freely through the entire mass. We will designate these "regenerative chambers." Instead of directly using solid coal as fuel, we will replace the ordinary fireplace by a large gas-generating furnace, not like that which we have described above for burning peat, but consisting simply of a chamber having a "step-grate," such as is above described. The generator may be near, or at any convenient distance from the furnace; and coal of a very inferior description may be burnt in it. The conditions must be such that carbonic oxide and combustible hydrocarbons may be generated, and conveyed through flues into the interior of the furnace. Let us now suppose that two of the regenerative chambers have been raised to a high temperature. Instead of allowing our gaseous fuel to pass directly into the furnace, we will cause it to traverse intermediately one of these heated chambers, whereby its temperature will be greatly raised and that of the chamber lowered in a corresponding degree; and we will only admit the air intended to support combustion through the other heated regenerative chamber, so that it also may be strongly heated. Thus both the gaseous fuel and the air for burning it enter the furnace at a high temperature. But, while this is going on, the products of combustion must, on their way to the stack, be compelled to traverse the other two cold regenerative chambers, to the brickwork of which they will in great measure deliver up their heat. When these shall have become heated, the other two chambers will have become cooled; and then we will change the direction of the currents, diverting the course of the gaseous fuel and the gas intended to support combustion, and sending them through the last heated chambers respectively. And thus the process may be continued, alternating from time to time the direction of the currents. It is obvious that by this means the waste heat is in a great measure caught by the brickwork in the regenerative chambers, and subsequently restored to the furnace. So much, indeed, is this the case, that when the interior of the furnace is white-hot the temperature of the products of combustion escaping from the chimney does not exceed three hundred degrees Fahrenheit. The temperature which may be attained in the furnace is enormous, and may be regulated to a nicety. Prof. Faraday, in a recent lecture before the Royal Institution, London, described in eloquent terms the impression produced on his mind when he saw these furnaces in operation at a large glass manufactory in Birmingham. One furnace contained twelve pots, each of which held *two tons* of glass; and yet, on one occasion, so high was the temperature, that the whole was actually melted down! If we reflect, we shall perceive that Siemens's principle is precisely that on which a handkerchief is tied round the mouth, or a "respirator" applied to it on a frosty day. The word "accumulative" would, probably, be more expressive than "regenerative." There is no regeneration, but simply retention and accumulation.

Of *Patent Fuel* there were numerous examples illustrative of various patent processes. In general the principle upon which these preparations is based is the agglomeration of fine coal, which is effected by the intermixture of pitchy matter. The compound is fashioned in bricklike or cylindrical lumps of convenient size under pressure, with or without the application of moderate heat, according to circumstances. Elaborate machinery for preparing this fuel was exhibited in the Belgian department.

India-Rubber Substitute. — In the section of India-rubber goods, an exhibition was made of the so-called "campticon," or India-rubber substitute. This new product is made from oxidized oil, so treated as to remove all unctuous matter, and is formed into a semi-elastic resin, which for many purposes, such as steam-packing, driving bands, and hose, is said to answer equally as well as India-rubber, at a considerable less cost. It can be supplied in either dough or solution, and as a hard compound vulcanizes as readily as India-rubber, without the use of sulphur.

Artesian Well-boring. — It was stated in connection with certain improved machinery exhibited for boring Artesian wells, by Degousèe, of Paris, that to such perfection has earth-boring been now carried, that solid cylinders of the rocks, perforated at extreme depths, may be obtained in the position which they occupied, and the actual dip of the strata may be ascertained by measuring the inclination of the planes of bedding with the axis of the cylinder.

Novelties in Textile Fabrics. — In the French department were shown the results of some attempts to apply photography in the production of an imitation of lace on silk, and especially on ribbons. This is effected by means of zinc plates on which the figure of lace has been printed by photography and afterwards etched. The process has been named "autophotes," and is probably not unlike photozincography. The effect of the printing is very good as seen at a distance, and also when applied to millinery purposes, that is, made up; but on close examination looks coarse, and seems uneven in the intensity of the lines and figures.

The wonderful advance recently made in "pigment" printing on textile fabrics (called also steam-printing) was especially noticeable in a display of printed muslins, in which art seems carried to its utmost limits on such materials. The style has received from the French the name of "*haute nouveauté.*" "In these printed muslins," says a recent art critic, "we have elaborate designs, chiefly floral, carried out with a breadth of 'handling' and delicacy of 'pencilling,' so to speak, that nothing except the most masterly treatment with indian-ink washes and the sparing but judicious introduction of color can achieve, even on paper. The use of aniline tints gives great brilliancy to some of these touches of color; and the drawing of the flowers, ferns, etc., is exquisite, in fact as perfect as French art can make it."

In the Russian department a curious exhibit was made of calicoes designed especially to meet the tastes and requirements of the rude people of eastern and central Asia.

As an illustration of the great and increasing demand made by the world for certain descriptions of cotton goods, attention may be here called to the fact that, notwithstanding a great development of the business of calico-printing within the last ten years in the United States and upon the continent of Europe, yet Great Britain, which in 1851 exported six and a half millions of pieces, increased her export in 1858 to upwards of thirty millions.

The extraordinary development of the manufacture of jute in Great Britain within the last few years was illustrated by a great variety of specimens, as, for example, twilled stair-carpeting, Brussels, Kidderminster, and Venetian carpets and hearth-rugs, in which the colors usually employed in woollen articles of the same class were successfully dyed in jute. The greens were especially good, and the effects produced were tasteful and well adapted to the purpose. The only drawback is that the dyes in jute are not permanent; but when the fact is borne in mind that a good jute carpet can be obtained at about half the price of those of the ordinary make, and that actual wear, apart from the fading of the colors, is in favor of the jute, the economical value of the material for use, if not for appearance, is at once seen.

Touching the value of the jute manufacture in Great Britain at the present time, it may be interesting to state that about 40,000 tons of this material are worked up annually, and that from recent returns it has been calculated that from 30,000 to 35,000 spindles are employed in spinning this material for weaving, and, as the supply is almost unlimited, it is difficult to calculate what results may yet be arrived at through its use in other directions than those in which we have just reviewed its successful application.

Perfection of Cotton Machinery. — Some interesting facts illustrative of the perfection attained to in cotton-spinning, as deduced from an examination of muslins shown at the Exhibition, have been published by Mr. H. Houldsworth, a leading Manchester manufacturer. It has been stated that the fine cotton yarn spun in India by female hands is finer than that spun by machinery in England. Mr. Houldsworth, however, shows this is not the case. He states that he examined the finest piece of Indian muslin exhibited in London, in 1851, and found that it measured 10 square yards, weighed 1,507 grains, contained 104 warp threads and 76 weft threads to the inch, the number being what is denominated No. 357. At the same Exhibition No. 400 English yarn was shown, but at the recent Exhibition there was a piece of muslin, woven in France from No. 700 yarn spun in Manchester, which exceeds anything ever before attempted. It is a mere fancy specimen, however, and not fit for practical purposes. On the other hand, there was a whole piece of cloth, of about thirty yards in length, made of No. 440 yarn. This cloth was also woven in France, but the yarn was spun in England of Sea Island cotton. The fine muslins of Hindostan have been called, in oriental style, "woven wind," but they are evidently coarse compared with the finest specimens that have been woven in France. Mr. Houldsworth states, as an item of curiosity, that a few threads of No. 2,500 have been made, but they are of no practical use. A single fibre of Sea Island cotton is equal in fineness to No. 8,000 yarn, and a pound weight of it in a single fibre of thread would measure 3,818 miles in length.

All the new dyes and chemicals of importance introduced during the last ten years into the manufacture of printed and dyed fabrics were shown in a great variety and richness of specimens; — prominent among them naturally being the products derived from coal-tar. Of aniline purple, there was shown by Perkin, its inventor, a cylinder of "mauvé paste," of so moderate dimensions as to be easily carried under one's arm, which required for its production the tar derived from 2,000 tons of coal. Its value was given at $4,000, and its "tinctorial potentiality" as equal to 100 miles of calico. In juxtaposition with this, on one side, was to be seen a large jar containing one grain of the paste dissolved in two gallons of water, to show the intensely colorific property of this material, and on the other side another jar containing about two gallons of crude coal-tar, the exact amount necessary to produce ten grains of mauvé dye. Aniline colors were also shown in their varied forms of dyeing and printing as applied to cottons, cotton-velvets, silk, and woollen, in shades of purple, reds, and blues, known as mauvé, magenta, etc. These colors in silk were especially brilliant. There were also illustrations of murexide colors, or the so-called "Roman purple," derived from the uric acid contained in guano. Pigment colors fixed by albumen and substitutes for albumen, such as lacterine, gluten, etc., were also shown, and coal-tar colors in combination at one operation with dyeing and printing. Specimens of emeraldine, a new green, and azurine, a new blue, were exhibited by Mr. Crace Calvert. Of these, emeraldine is produced by preparing cotton with chlorate of potash, and then printing with an acid chloride of aniline; in a given period a bright green appears; then the green is subjected to the action of a solution of bichromate of potash, and the tint is changed to a deep blue, which has been called azurine.

Engraving and Printing.—In this department the novelties which seemed most worthy of specification were, first, illustrations of a process (not new, see *Annual of Scientific Discovery*, 1861, pp. 68, 69) for enlarging or reducing impressions from engravings, through the elastic power of India-rubber. Thus a picture is first printed on a sheet of vulcanized rubber prepared with a surface to take lithographic ink; this is then stretched to any required size, and the enlarged impression transferred to a lithographic stone, from which other impressions on paper may be taken in the usual manner. When it is required to make a reduced copy of a drawing, the process is reversed. There is now on exhibition in London a series of enlarged sketches in oil from Punch by John Leech, which have been formed in this way from the original wood-cuts stretched and painted over. Second, lithographs transferred to copper and chemically treated to become surface-blocks by Giessendorf of Vienna; third, engraved photographs on wood, with which the draughtsman has had nothing to do; fourth, one of Hogarth's engravings, reduced and engraved by the action of light, producing a repetition that would puzzle a connoisseur to make out, the work of Sir Henry James; and, lastly, specimens exhibited by Mr. Willis of what he calls autotypography—a process by which he is enabled to impress in a plate of soft metal an artist's own drawing, even to his washes and delicate renderings, provided they be done upon the transparent medium supplied by him, somewhat as drawing upon tracing paper, an easy and facile method, requiring no reversing of the subject or writing.

Engraving by Electricity.—An ingenious, though not very new machine, was exhibited for engraving copper cylinders employed in the printing of textile fabrics by means of electricity, its distinctive feature being the application of voltaic electricity in communicating certain necessary movements to important and delicate portions of the apparatus. The cylinder to be engraved is first coated on its outer surface with a thin film of varnish, sufficiently resistant to the continuous action of the strongest acids. The requisite number of copies of the original design are then traced or scratched simultaneously by a series of diamond points, which are arranged on the machine parallel with the axis of the cylinder. Each diamond point is in correspondence with a small temporary magnet; and the entire series is so arranged *en rapport* with the original design, which had been previously etched on a metal cylinder fitted in with a non-conducting substance (this cylinder being made to revolve in contact with a tracing-point), that when the electric current passes, intermittent currents are established, whereby the diamonds are withdrawn from their work at the proper intervals. The metallic surface is thereby exposed in certain parts, and a bath of nitric or other acid being afterwards used to etch or deepen the engraved portion, the operation is completed. By means of this apparatus, engravings may be enlarged or diminished to any necessary extent from the same original.

Agricultural Implements. — The display of different devices for steam-ploughing was very extensive, but embraced no construction of novelty. Many styles of the agricultural locomotive engines which have come into extensive use in Great Britain were shown, each being applicable to the various uses of steam in farm-work, as threshing, chaff-cutting, etc. Each engine is constructed to transport itself and its apparatus from one farm to another, and in neighborhoods where the roads are good they succeed well. A very cheap stationary cast-iron boiler for farm or conservatory purposes, where only fifteen or twenty pounds pressure is required, was deemed worthy of a first-class medal. The boiler was tubular, and cast all in one piece; the exhibitors claiming that this plan of construction effectually prevented breakage and leakage by expansion and contraction. There were also exhibited iron stalls for horses, admirable for fitness of design and completeness of finish. The rack, manger, and water basin are all of iron, the manger and basin lined with white porcelain enamel. The floors are of brick, or wood, or grooved iron, as preferred, but each is provided with a perforated iron gutter. Wood is preferred for the partition walls, as iron has been sometimes broken by a kick, to the damage of the kicker. Halter-straps weighted so as to prevent all possible entanglement, and zinc rollers at the edge of the manger to prevent crib-biting, were accompaniments of these stalls. A *patent safety-spring*, to prevent horses from running away, exhibited, consisted of an elastic India-rubber strap, about a foot long, one end being attached to a common straight bit, the other buckled to the riding or driving rein, which is attached to a curb bit. The point of junction is so adjusted that ordinarily the horse will feel only the small bit, whereas, in case of sudden restiveness, a heavier pull on the rein brings the curb to bear. This simple contrivance may be applied to any riding or driving bridle, and for tender-mouthed horses who will not bear the curb, but still like to run away occasionally, it is invaluable.

A Danish Milk Pan, for large dairies, which was honored with a medal, was of iron, lined with white porcelain enamel; the dimensions six feet by two and a half feet. It was so arranged that one end may be easily raised to pour out the milk as desired. The cream is removed by means of a long-handled skimmer, a light strip of wood between two wheels, adjusted to travel down the edges of the pan, pushing the cream before it into a reservoir stationed at the end to receive it. This reservoir is placed on wheels, and may, if the row of pans is long, have a railway of its own to travel over. A Swedish pan, of tin, provided with a perforated tube through which the milk is allowed to pass out, leaving the cream in the bottom of the pan, was also awarded a medal.

Bricks and Tiles. — An English hand machine for making tiles for drainage, and hollow brick for building purposes, received a medal in this class, as an implement adapted for the use of farmers. A man and two boys, it was stated, could make with it 7,000 tiles of 2½-inch bore and 13 inches long, or 3,000 hollow brick, per diem. The price

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was about £20. A large steam-power machine for the manufacture of both solid and hollow brick was shown in operation, by H. Clayton & Co. This machine was a "combined three-process machine" for clay-crushing, pugging, and brick-moulding at one time. It is worked by a 12-horse power engine, and is capable of turning out from 20,000 to 30,000 solid, perforated, or tubular bricks per day, according to the quality of material used. The exhibitors claimed that, combined with their patent system of kilns and drying apparatus, these machines have, where they are adopted, reduced brick-making to a regular factory system, which can be carried on, independently of seasons or weather, uninterruptedly throughout the year. The peculiar mechanical difficulties necessary to be overcome in the production of a practically successful brick-making machine do not seem, however, to have been as yet accomplished. All experiments, necessarily, have had to be conducted on one of two essentially different principles: by "compression," *i. e.*, forcing the clay, either in a wet or dry state, into moulds to form the brick; or by "expression," *i. e.*, forcing the clay, in a plastic state, through a die which should consolidate and shape it during its passage. Both processes have been extensively and variously tested. With the former, great difficulty has been found in perfectly filling the mould, whether with wet or dry clay, the lower corner of the brick remaining imperfect, even after the clay had been submitted to enormous pressure while in the mould. Another difficulty was in delivering the brick from the mould rapidly, and without injury to its form. In the use of dry clay, the inconvenience from each of these causes was, perhaps, somewhat less felt, but this involves the erection of an apparatus for crushing and sifting, beside the cumbrous and expensive pressing machine, and the quality of brick so produced is not generally admitted to equal that made from plastic earth. In the "expressing" machines a serious difficulty was experienced at the outset in moulding through dies so as to form a perfect rectangular stream of solid clay, the increased friction at the angles of the stationary plate die causing the mass to come out ragged at the edges, at times fracturing even the brick itself. Very many methods have been tried for obviating this difficulty, and in the Clayton machine, above noticed, it is claimed to have been effected by giving to the die orifice revolving sides. The working surface of the die-rollers is, further, constantly lubricated by means of branch supply pipes passing down from a water reservoir above. The clay comes out alternately on the two sides of the machine in a continuous, smooth, and solid stream, with sharply-defined angles, and there remains only to cut it in proper breadths for forming bricks. There were, beside this, a score of brick-machines exhibited in the building, from Great Britain and various European countries, indicating that whatever apathy may have existed on this subject in the past, there is none now, and that the days of hand brick-making are over; for from among so many, each possessing, doubtless, some merit peculiar to itself, there must, ere long, be educed a machine for manufacturing "perfect bricks" with economy, even if it has not already been effected.

The display of glazed stoneware in the English department was most extensive and interesting. As examples of novel applications we may mention two large cisterns, the one cylindrical, the other rectangular. Both were built of hollow blocks, glazed on both sides, and fitted together with a double dove-tail laid in a fine water-proof cement, and forming a solid wall. They were clean and excellent, and probably cheap and durable, as was stated of them. At the same stand were large kegs of the stoneware so grained and colored as to require close inspection to convince one that they were not really made of oaken staves with hoops of brass, as they seem to be. They were neatly fitted also with faucets of earthenware. These last are much in favor in England for general purposes, being most perfectly fitting and trustworthy.

The display of ornamental tiles, made by the well-known firm of Minton & Co., was especially interesting, as showing the great variety of uses to which these colored plaques of various materials have been applied. In addition to their use for the flooring of door-steps, conservatories, and halls, they are now applied for the adornment of the fronts of shops and houses and for inner walls of apartments. In bathrooms, particularly, the use of these tiles for overlaying vertical surfaces is most desirable, inasmuch as they are impervious to wet, and give to the wall a highly ornamental appearance.

Furniture. — Chairs in which painted panels were introduced in imitation of mediæval work appeared quaint, but rich and beautiful. It may fairly be questioned whether it is judicious to place pictorial works in a position in which they are hidden when the object which they adorn is in use; but, allowing such to be legitimate, these were placed in a very skilful manner, for the panels were small and deeply sunk, so that the projecting styles fully guarded them from injury, and the large central panel against which the back rests was filled up by a projecting cushion. Cabinets and chairs enlivened with plaques of colored stones, and others which had the curved surfaces of their mouldings enriched with inlays as well as the flat surfaces, were other noticeable objects. Library furniture in the Pompeian style was both novel and beautiful.

Jewelry and the Precious Metals. — One of the generally acknowledged gems of this department of the Exhibition was a silver table in *repoussé* work exhibited by the famous electro-platers, the Elkingtons, and executed by M. Morel Ladeuil. *Repoussé* work, we may premise, is the slowest and most difficult mode of working in silver. The relief on the metal is all beaten out from the inside by means of an iron rod, one end of which is placed in contact with the plate, while the other is struck by a hammer. When skilfully performed, the labor is repaid by the superb effect obtained. The value of the table under notice, *i. e.*, as a work of art, was sixteen thousand dollars, and the time consumed in its manufacture was three years. The subject of the work is Sleep, — the drowsy divinity, the terminal figure at the top, scattering poppies over three statuettes, from which the stem of the table springs, — a minstrel, a soldier, and a husbandman. The varied dreams of these three are represented in the circumference of the table above, and represented with such power, and such breadth and depth of shades, that, with the soft tone of the oxidized silver, the effect of this portion of the work rather resembles the proof of a fine engraving than a design hammered out of the solid silver. The art of enamelling on precious metals in the high artistic acceptation of the term has been virtually lost to jewellers for the last century and more. In India it still lingers among a few families of the native jewellers; in Europe it has almost disappeared. The Messrs. Elkington, of England, are now making an effort to revive this lost art, and exhibited numerous objects illustrative of their progress and success. The pattern is first cut out of the metal; on the hollow spaces thus formed the enamel is placed, and fused under a violent heat. When cool, the rough surface is polished on a stone lathe. A dessert service in this style was very beautiful, being in the Pompeian style, the enamel employed being turquoise blue, red, and black. Its value was ten thousand dollars. A magnificent electro-plated dinner service, some of the pieces of which were executed in the enamel style,—made by this firm for the Duke de Brabant,—though not of silver, was so elaborate in its design, and so finished in its execution, that its actual cost was estimated at thirty thousand pounds—one hundred and fifty thousand dollars. Messrs. Hunt & Roskill, of London, displayed an elaborate silver candelabra, made for the Marquis of Breadalbane, to display his celebrated collection of the Poniatowski gems. It was so constructed as to hold lamps, round the globes of which, in silver-gilt bands, the gems were set, so that the light shines through them, displaying the colors of each, and the minute design which enriches them. The body of the candelabra, from which these branches spring, likewise contains a magnificent belt of gems, and into this, also, a light is introduced to set them off to the best advantage. Between the *plaques* of *repoussé* work here, the body of the vase is filled up with iron, damascened all over with the most exquisite and minute arabesques in gold.

Emanuel, of London, showed a gold cup, representing the fable of Perseus and Andromeda, in which advantage was taken of the peculiar form of a very large topaz to cut it into the shape of a small nautilus shell, and this stone forms the cup proper. All the rest of the work, the stand, stem, etc., was of gold enamelled. The dragon, a most Raffaelesque monster, is made to subserve the purpose of a handle, and waits, open-mouthed, for the descent of Pegasus and his rider. This cup sold during the Exhibition for $10,000. In the same case with the above was exhibited a very fine specimen of gold work in the shape of a toilet mirror, which was made for the late Sultan of Turkey, as a present for one of the ladies of the harem. Its cost, it being profusely adorned with precious stones, was £10,000 ($50,000). With this another present was to have been made to the same favored lady, of a stereoscope in ivory, enriched with rubies and emeralds; and this costly work was also shown, though, as the laws of optics could not be moulded to suit the requirements of jewellers' tastes and fashions, the stereoscope in its dress of jewels remained quite as angular and ugly in regard to shape as one of common mahogany.

In the speciality of precious stones, the display of the Exhibition was, probably, the finest and most extensive the world has ever seen. It embraced the well-known Koh-i-noor, with a companion diamond, weighing seventy-six and one-half carats, belonging to the queen; the celebrated "Star of the South" diamond, larger than the Koh-i-noor, and owned in Amsterdam; and three of the finest rubies known, which, found in the treasury of Lahore, India, were confiscated and given to the queen. They are engraved with dates of the Mohammedan era from 1070 to 1168. Other curiosities were — an emerald, almost without a flaw, weighing one hundred and fifty-six carats; another emerald, imperfect, weighing three hundred and seventy-seven carats, and claimed to be the largest in the world; a ruby, weighing one hundred and one carats, and a small profile likeness of the queen, not much larger than a postage-stamp, which was composed of nearly twelve hundred minute but distinct diamonds. Emanuel, the celebrated London jeweller, showed many specimens of an old fashion of setting precious stones in ivory, that is, "ivory-jewelry;" and a more attractive setting for some kinds of gems, viz., that styled the "pink coral" jewelry. This material, however, has nothing to do with coral, the pink base in which the jewels are set being cut out of a delicately-tinted shell found in the West Indies, which much resembles rose-colored mother-of-pearl. With the aid of this shell and the ivory some remarkably beautiful combinations are produced, especially when the jewels are carefully chosen to suit the settings.

Other novelties in jewelry were the so-called "rock-crystal brooches," engraved like intaglios, and painted from the back; their curiosity consisting almost entirely in the excellence of the painting, which requires great skill, inasmuch as the first touch of the brush must also necessarily be the last; the "granite jewelry," manufactured in Aberdeen, Scotland, some specimens of which were very fine, the grain of the stone revealing depth and richness of hues; and a cup, taken from the Emperor of China's palace, made of a human skull, inlaid with precious stones and supported upon a massive gold pedestal.

In the French department a most curious exhibit was made of artificial pearls and gems. One exhibitor showed ten strings of pearls, one, real, valued at twenty thousand dollars, and another, false, worth two hundred dollars, and defied connoisseurs to distinguish, by sight alone, between the two. The false gems, for which the French are so justly celebrated, were exhibited in every stage of manufacture, from the mass of paste composition in the crucible to the cut and set stones. Here, again, the eye is completely at fault, the taste of the manufacturer leading him to discard all extravagances, the more completely to deceive. The price of these fictitious gems was, however, very high.

Aluminum was shown in a great variety of useful and ornamental forms. We would specify soldiers' helmets and sextants, both wonderfully light; also door-keys of aluminum alloyed with a small percentage of nickel. A fine display was made of fancy articles composed of ten parts alloyed with five of copper, the whole an alloy of great hardness, of the exact color of gold, and almost as free from liability to tarnish as the precious metal itself. At present the price of aluminum has fallen to about seventy cents per ounce, and for jeweller's work one ounce of aluminum will go as far as five or six of silver. M. Garepou, of Paris, now furnishes aluminum wire at from sixty to one hundred per cent. cheaper than silver wire of the same size. He exhibited in the Exhibition articles of lace-work, epaulets, textile fabrics, head-dresses, etc., with mountings and ornaments constructed entirely of aluminum.

In this department was exhibited an ingot of platinum, weighing over two tons.

PAINE'S SPRAY SUPERHEATED STEAM-ENGINE.

This engine, for which steam is generated on a very ingenious principle, differs from an ordinary steam-engine in the following essentials: For the latter, as everybody knows, a boiler is used containing a considerable quantity of water, to which the heat of the furnace is most directly applied, and from which the steam is generated. Such a boiler is a magazine of force, because it contains a far greater amount of steam and heated water than is required to supply the engine at each stroke. Herein consists the danger from explosions in common boilers. A hot-air engine has no magazine of force like a steam-boiler. Its heater is supplied with the exact amount of air requisite for each stroke, hence its immunity from explosion. This new engine embraces a similar principle. It has a peculiarly constructed heater, into which the exact quantity of water for each stroke is fed in the form of spray, then it flashes into steam, and passes over an extended heated surface to the working cylinder.

A single acting engine, working in New York, has the following dimensions: — Its steam cylinder is seven inches in diameter; the stroke of piston, seven inches. It is situated upon a small tank thirty by thirty-four inches, which forms the bedplate and the heater of the feed-water. The feed-pump has a stroke of one-fourth of an inch, and the water is fed through a quarter-inch pipe. The steam-heater, outwardly, resembles a vertical cylindrical stove. It is thirteen inches in diameter, and thirty inches in height. There are nineteen double tubes inside, and the steam passes between these, and is heated on two sides. The circular grate, containing the fire, is capable of being adjusted by a lever, and set at any required distance from the bottom of the heater. The steam exhausts into the tank upon which the engine stands; the feed-water, nearly at the boiling temperature, is conveyed into the heater in a fine shower through a small conical chamber on the top of the heater. A small quantity of superheated steam is contained in the heater, and the feed-water, in the form of spray, is instantly converted by it into saturated steam. The pipe for supplying the cylinder with steam is situated nearly at the bottom of the heater; hence the saturated steam formed from the feed-water at the top of the heater has to pass in a current between the double tubes on its way to the cylinder, and it thus flows over a very extended heating surface and becomes superheated. A constant current of steam is maintained in this manner over the heated surfaces of the tubes. By such a heater and such arrangements of the parts of the engine, nearly all the heat is economized, and a perfectly safe steam-engine is secured. If the feed-pump were to cease working or the supply of water to become exhausted, the heater would become like an empty oven after a few strokes, and the engine would stop of itself. For pumping water, printing-presses, sawing wood, and various operations requiring a small motor from one to ten horse-power, this engine appears to be well adapted, as it is compact, safe, and easily controlled. — *Scientific American.*

THE PNEUMATIC DISPATCH.

The principle of forcing packages, etc., through a tube or conduit by means of atmospheric pressure, is about to be applied practically and upon a large scale in London (see *Annual of Scientific Discovery*, 1861 and 1862) for conveying or pumping the mail from Easton Square (a great railroad depot) to a post-office station some miles distant. The tubes to be used for this purpose, and which are to be laid underground, are about three feet in diameter, and of the form of a horseshoe. At the bottom of the two sides of the tube is a slight projection, which does duty as a line of rails, on which the carriages roll along. The latter have a board behind and in front, which fits into the tube, but by no means in an air-tight manner. It is said that this is not in the least necessary, and that it was a great mistake on the part of former schemers in atmospheric railways to encumber their tubes too much with wadding and bolstering, which led to a greater loss by friction than was gained in power. To allow for the inequalities of the tubes, there is more than half an inch space between the outer shell of the boxes and the inside of the iron pipe, and it is found that even with this margin they travel at the rate of forty miles an hour. The tube is exhausted by an apparatus called a "centrifugal disc," consisting of a hollow wheel, twenty-one feet in diameter and but a few inches in thickness, which in its centre literally sucks up the air and discharges it at the outer edge. This is effected by a division of the disc into a number of small chambers, which act like so many fans in gathering and emitting the air. It is a very simple and beautiful contrivance, which is found to work admirably, much more efficient and very considerably cheaper in its action than an air-pump. A small steam-engine puts this disc in movement to the time of from two hundred to three hundred revolutions a minute. It requires but a short time to exhaust the air of a tube several miles long to a sufficient extent to propel a whole train of letters and parcels. Judging from the success of the experiments already made, the scheme bids fair to be realized before long on a grand scale, and produce a revolution in the dispatch of letters as great at least as that of the introduction of the penny-postage. There seems no reason, indeed, why our letters should not be carried to us in pipes underground as well as our gas and our water.

THE MONT CENIS TUNNEL.

As the work on this great tunnel is now advancing, day by day, with such a regularity and success as to render it one of the most wonderful of engineering feats in the world's record, a brief review of the history and progress of the enterprise will not be found uninteresting.

The tunnel, it may be premised, is in the course of construction under the auspices of the Sardinian government, and is intended to subserve the purpose of railway communication between Piedmont and Savoy. It passes beneath what is known as the Frejus Ridge, in the vicinity of Mont Cenis; has an average depth of about a mile below the surface, and a length of about eight miles. As shafts a mile in depth were out of the question, it was determined in the outset that the tunnel should be worked from the extremities alone; that is to say, that four miles should be worked from one end and four from the other. These conditions, however, involved two great difficulties: one, the immense time which it would take to excavate so long a tunnel from both faces, and the other the apparent impossibility of ventilating it during the progress of the work. In order to obviate these difficulties, various plans were proposed, but, after considerable consultation on the part of the engineers intrusted with the matter, the following arrangement was adopted. Air in the first instance is forced into reservoirs, from whence it flows uniformly through a tube into the interior of the tunnel or heading. This air is first used to work the tools for drilling holes in the face of the rock, and then allowed to escape in the tunnel-shaft, which last secures a perfectly good ventilation.

As this hydro-pneumatic machinery is the principal agent used in carrying out the work, it is necessary, in the first instance, to get a clear idea of the manner in which it acts. Some 30 or 40 yards above the level of the plain there is a reservoir of water, filled by a canal that is fed by a supply from a mountain torrent at some considerable distance away. From this reservoir there are ten iron cylinders laid on beds of masonry against the steep slope of the mountain, each of which can be made to receive the water from the reservoir by opening valves up above, in which case the water rushes down into iron reservoirs for storing the air, one of these last being connected with each tube that is laid against the side of the mountain.

The way in which the air is forced into the iron reservoirs is as follows: Each tube that comes down the side of the mountain, and which is about two feet in diameter, is continued on some ten or twelve feet below the floor of the *atelier*, or building in which the reservoirs are placed, after which it is bent and rises up perpendicularly, or rather the main tube communicates underneath with a hollow vertical column from 12 to 15 feet high, in the top of which is a valve opening downwards; there is also another valve to separate the sloping part of the tube from the horizontal portion. The whole of the tube, including the sloping part between the water reservoir on the side of the mountain and the flow of the *atelier*, the horizontal part beneath the floor, and the vertical part which rises in the *atelier* some 12 or 16 feet, form altogether a siphon, in which not only the weight of the water acts, but also the momentum of the water descending all the way from the lofty mountain ridge whence it originally proceeds. We may suppose the whole of this siphon filled by water, to begin with. The first operation then, in working, is to close the valve at the foot of the sloping part, and afterwards to discharge the water in the horizontal and vertical portions of the tube; this being done, the valve at the top of the vertical column falls down and admits the air. The valve at the foot of the sloping tube is then reopened, and the one at the top of the vertical column closed; the water then rushes in and compresses the air in the shorter end of the siphon to six atmospheres. This water afterwards is discharged as before, and fresh air admitted; but it should be understood that when the air is compressed in the upper portion of the vertical cylinder it passes away at once by small tubes into the iron reservoir (which is of the shape of a pontoon). Each contains nearly 5,600 cubic feet of air, is about 33 feet long, and nearly 6 feet in diameter. All these operations are effected in much less time than it takes to describe them; and the opening and shutting of the valves of *alimentation* and *discharge* are effected opportunely, without the intervention of human aid, thanks to the automatic action of a small apparatus, regulated suitably by a column of water.

The air in passing from the upright column into the reservoir loses some of its density, and has only a pressure of four and a half atmospheres. The bottoms of the reservoirs are filled with water, which is displaced as the compressed air enters; this is supplied by the smaller tubes, which descend the side of the mountain between the larger ones, that is, they have five large water tubes on either side of them. These reservoirs are furnished with water-gauges, by which the quantity of air and water in them may be seen and regulated at any time by the mechanical engineer in charge of the works.

The cylinders being always kept sufficiently full, according to the judgment of the engineer, the apparatus is constantly in working order; and the operations of boring the holes for blasting in the heading, and a constant supply of fresh air in the tunnel, are a natural consequence. But before proceeding to describe the operations of the boring-machines, and how they are put in motion, we may mention that 7,924 strokes of the machinery per day produce about 51,000 cubic feet of compressed air, which flows away into the cylinders of the boring-machines, and eventually into the tunnel, which it ventilates admirably.

The principle of the machinery for boring is extremely simple. The machinery consists of two essential parts, — one the apparatus for driving the cutting tool into the rock and withdrawing it, so that the blow may be repeated while at the same time it is made to take a whole turn on its axis, now towards the right and now towards the left; and the other, the machinery for advancing the bed on which the cutting tool rests as the work goes on, so that the auger or borer may constantly advance as the hole is being bored, and may be kept well up to the surface it has to operate upon. Both portions of this machine are worked by means of the compressed air.

The first or cutting part of the machine is a long borer, which in reality is fixed upon a continuation of the piston-rod, working in a cylinder into which the compressed air is admitted fore and aft alternately, so as to drive the piston forward against the rock and withdraw it by a back and forward motion, while a turning motion is given at the same time. The edge of the borer is in the shape of the letter Z, so that, in turning and returning, the substance of the rock is ground away in the hole, as well as pulverized by impact.

Six of these borers, with the machinery for driving them forwards, six reservoirs containing water, which is forced in a constant jet into the hole while the boring is being performed, so as to facilitate operations and clear away the *débris*, and apparatus for lighting by gas, are mounted on a railway-carriage frame, and the whole works in a heading 11 feet 6 inches by 11 feet. It drives holes in the rock varying from 2 to 3 feet in about twenty minutes. These holes can be bored either horizontally, vertically, or obliquely; as many as eighty are sometimes driven in the face; but they are not all charged with powder, the object in making most of them being merely to facilitate the breaking up of the rock when the powder explodes in the others. When the holes are bored the machine is drawn back upon the rails to a distance of about fifty yards; great wooden doors are then shut to prevent the blasting from doing any injury to the machinery; and the holes are filled with powder, the fuse being used to ignite it. The blasting takes place twice in twenty-four hours. The machine is removed the fifty yards and returned to its place in ten minutes.

It requires a long time to get rid of the foul gases produced by the explosion of the powder: it is found that from one to four hours and a half are necessary to remove the vapors and the *débris*. From this cause not more than about five feet of the heading can be done per day on each side, at which rate the tunnel would not be done for ten years; but there are machines being made now which it is calculated will effect a saving in time of 30 per cent.; so that, if nothing unforeseen happen, the whole tunnel can be finished in about six years more; or, if new improvements are successfully introduced, it may be completed even in a less time still; and this will very probably be the case, for there are means of using the machines more expeditiously, and experiments are being made to see how far they can be taken advantage of.

However that may be, the great work is now assured, and it is only a question of time; the machinery is so perfect that everything goes like clockwork; and the great desideratum of making a long tunnel without shafts having been obtained, there need now be no further doubt about the success of such undertakings.

The sides of the Mont Cenis Tunnel are lined with the stone excavated in the tunnel itself, nicely worked, while the roof is lined with four rings of brickwork. It should be also stated that there is a main tube which passes over the ten iron reservoirs, and this is in communication with them by means of short pipes; this tube is continued to the far end of the tunnel, and conveys the compressed air to the boring-machines, into which the air enters by means of small pipes of vulcanized India-rubber.

The tunnel has vertical walls and a semicircular roof; the lining is carried about a foot below the roadway, and makes a mitre joint with the rock, so as to convert the substratum into a natural invert. The tunnel itself is 26 feet 3 inches wide in the clear, and its height in the centre is 24 feet 7 inches.

The total length of the heading on the Italian side is 3,530 feet, while that on the Savoy side is 2,620 feet; and the length of tunnel taken out to its full dimensions, lined and finished, is about 6,000 lineal feet altogether.

In the headings there are constantly employed at each face thirty men to direct and attend to the working machinery; six men and three boys are kept for the purpose of blasting the rock; and six additional men are occupied, when it is necessary, to remove the *debris* after the blasting has taken place; besides, there are numerous workmen working the tunnel out to its full dimensions, lining it, and so on. The tunnel is at present in one straight line; but, in order to enable the trains to turn into the sharp valley, it will be necessary to have the entrance in a curve. The curved part of the tunnel is now being commenced, and will join the straight part at about 250 yards from its present temporary entrance on the Italian side.

The tunnel will have a continuous gradient, falling from the Savoy end towards Italy, at the rate of 1 in 500. It is to be regretted that the approaches are so steep, being on an average 1 in 50 on one side, and 1 in 40 on the other. It would have been far better to have made the tunnel somewhat longer, so as to have avoided a continual source of wear and tear, both of trains and rails, which will be a perpetual charge upon the line. The height of the tunnel at its Italian entrance above the level of the sea is 4,331 feet.

NEW RUDDER.

A new rudder, the patented plan of Mr. Lumley, has recently been put on trial by the English admiralty. Its peculiarity consists in its being cut in two vertically, and the two parts being connected together by gudgeons and pintles in a manner precisely similar to the ordinary method of hanging a rudder to a ship's sternpost. At the outer part of the rudder's afterpiece are attached two chains which pass through the main piece of the rudder, one on each side. The result of this arrangement is that on the rudder's being moved over either to starboard or port the chain becomes taut and brings the outer piece of the rudder over at a sharper angle than the main piece, and thus presents a hollow surface to, and obtains a greater hold on, the water than can be obtained with the ordinary rudder, and without bringing any very great strain to bear upon the gudgeons and pintles.

ELECTRIC TELEGRAPH AND GAS ON SHIPBOARD.

One of the new iron-plated frigates recently launched in Great Britain — the Resistance — has two specialities of equipment which are seldom found on board ship, — the electric telegraph and gas. The former forms a communication between the fore and after bridges, and by the officer of the watch, at sea, moving a handle on a dial-plate, a needle in a case hanging in front of the quarter-master at the wheel points to the signal wished to be given, — starboard, port, or steady, as required. The whole arrangement is very simple, and cannot well be misunderstood, either by the officer working the handle on the forward bridge, or the man at the wheel. The gas is manufactured from oil. The gasometer is on the upper deck, between the boom boats and before the main hatchway, in a small caboose. The oil, flowing from a reservoir through a small pipe, enters a retort, whence the gas generated by the heat passes into the gasometer. From the gasometer a pipe conveys the gas below to the engine-room and screw alley, which last is lighted by twelve burners.

DOUBLE SCREW STEAMSHIP.

The experiment of fitting a vessel with two screws and engines, working separately and independently of each other, has recently been made successful in England. The vessel in question is of iron, four hundred tons, and one hundred and sixty feet in length, having two independent engines and screws, with a collective nominal horse-power engine of one hundred and twenty horses, the screws working under each quarter, and consequently before the rudder, in lieu of the present system of one screw astern and abaft the rudder. The use of two screws in the propulsion of ships is nothing new; but this, it is stated, is the first instance in which a vessel has been fitted with two screws and engines working separately and independently of each other; and herein lies the value of the principle in a military point of view, as giving a ship a means of rapidly revolving under steam, and changing her position to any required point. In the trial trip, the following experiments were made with a view of testing the capability of the ship for rapid turning within a small space. The first was made with both engines, going ahead at full speed, and the helm hard over, when the first circle was made in three minutes and fourteen seconds, the second in three minutes and thirteen seconds, and the third in three minutes and sixteen seconds, the diameter of the circles being about three lengths of the ship, and lessening each time. In the second experiment, one engine and screw worked ahead, with the other going astern, and one circle was made in three minutes and thirty-nine seconds, and another in three minutes and forty-nine seconds. In making these circles, the action of the ship's hull was extraordinary, the central part being stationary, and both ends moving round equally; the circle was made on a pivot from the ship's midship section. The vessel was then put in a straight course, stopped, and from a state of rest the engines were started, one ahead and the other astern, the circle being completed in three minutes and fifty-five seconds, and the diameter of the circle being, as before, within the ship's length.

UNSINKABLE AND INCOMBUSTIBLE SHIPS.

During the past year there has been constructed and launched in England a screw-steamer, which is claimed by the builder, Mr. C. Lungley, to have two great and novel advantages, viz., safety from destruction by water, and, to a great extent, security against fire. Each deck of the vessel is distinct from the others, having no communication with them, but having its separate hatchway or entrance from the upper deck; the object of this arrangement being, that whatever injury may be incurred by either one, or even by two, of these decks or stories, the other or others will float. Thus, for instance, should the lower or keel deck be knocked away, the two upper decks will float the ship; or should, either from a collision, the starting of a plate under the water-line, or from a shot or a broadside penetrating the sheathing, one of the intermediate decks let in the water, even to the extent of filling the compartment from stem to stern, the buoyant power would still remain, and the vessel would not only float, but be perfectly manageable, the water merely rising up the trunk hatchway of that particular deck to the level of the water-line outside, allowing full opportunity for a diver to descend, find out the place and extent of the injury, and repair it if capable of repair, after which the water might be pumped out and the ship freed.

The same subdivision of decks which affords the security against entire submersion, ensures protection against total destruction by fire. In the event of a fire's being discovered on either deck, the hatchway of that deck would be fastened down, and, the supply of air being thus cut off, the fire would die out of itself; or if the fire had got too much hold upon the ship to allow of this, then the entire deck in which the conflagration was raging might be filled with water without risk of other inconvenience than that of having to pump it out again.

The practice of dividing iron ships into water-tight compartments, with the view of preventing their sinking, has been followed for many years, but the division walls have, in all cases, been transverse; that is, each deck has been divided by water-tight iron bulkheads into three, four, or more separate rooms or apartments, — the impression being that should one or two become by leakage filled with water, there would be buoyancy enough in the others to keep the ship afloat. Experience has, unfortunately, however, — and the case of the *Connaught* is a prominent instance among many, — proved the unsoundness of this theory. The fact is, that when any one of the compartments becomes filled with water, the vessel is unduly depressed, and no longer sails with an even keel; but by making the decks themselves the water-tight divisions, the weight of the water, in case of leakage, is equalized over the whole surface of the ship, and the even keel, which is the main element of safety, is preserved.

PROGRESS OF IMPROVEMENT IN WAR IMPLEMENTS AND CONSTRUCTIONS.

During the past year, the perfection of heavy ordnance, of projectiles, and of the art of defence, have constituted the chief topics of interest and experiment with the naval and military authorities of both Europe and America; but in spite of the most earnest and long-continued investigations on the part of different governments, "so little," says Capt. Dahlgren, in his official report to the secretary of the navy, Dec. 1st, 1862, "is yet positively known of the effect of ordnance and the resistance of iron plates in different forms, that the ablest and most experienced cannot agree in regard to the armor best calculated to oppose the most effectual resistance, or upon the cannon that shall be employed to overcome that resistance."

At the close of the year 1861, the general opinion in Great Britain and on the continent of Europe (founded on the results of the experiments at that time made public) was, that ships of war protected by iron plating four and a half inches in thickness were essentially invulnerable to the effects of shot and shell. (See *Annual of Scientific Discovery*, 1862, p. 84.)

In the spring of 1862, Sir William Armstrong having completed a new one-hundred-and-fifty-pound smooth-bore gun, additional experiments were made, under the direction of the English board of admiralty, and in the presence of a large number of scientific, military, and naval men, including agents of several foreign governments.

The target consisted of five and a half inches of the best plate iron, fastened with through bolts upon a teak timber backing nine inches in thickness. As an additional security, iron plates ten inches wide and one and one-half inch thick were let into the teak backing, and placed longitudinally at the back of the joints of the centre and top and bottom armor-plates. The target was, moreover, further strengthened by covering the joints of the skin plates, longitudinally, with five-eighths plates eighteen to twenty inches wide, let into the back of the teak, and bearing against the outside of the skin.

Four round shot were fired from the 150-pounder Armstrong gun. The first three were cast iron, weight one hundred and fifty-six pounds; the last wrought iron, weight one hundred and sixty-two pounds; the charge in each case was fifty pounds of powder; *the range, two hundred yards.* No. 1 struck the centre-plate (which is nine feet long and three feet and four inches wide) about two feet from the port, midway between the top and bottom edges. It penetrated the armor-plate, making a hole twelve inches in diameter, and, crushing through the teak backing, burst the ship's skin-plate open, making three large cracks, through which splinters of wood protruded behind, split one of the frames across, broke off the points and nuts of four armor-plate bolts, and four or five wood bolts. Several bolts of the plate above were started by the shock.

No. 2 hit the top plate (which, as well as the bottom plate, was about eleven feet long and three feet four inches wide), made a hole twelve inches in diameter through it, and forced a way through the teak backing and skin-plate. Large fragments of the armor-plate, including the front piece bearing the mark of the shot, were found on the ground ten or twelve yards behind the target, and five or six bolt ends and nuts were broken off.

No. 3 made a hole, of the same diameter as before, clean through the bottom plate. Large pieces of the shot and armor-plate passed through the target; the cone of the shot, imbedded in the portion of plate carried away at the moment of impact, was picked up some yards in the rear. In addition to the hole through the armor-plate, its upper edge was split longitudinally a length of two or three feet, showing the lamination of rolled iron.

No. 4 struck the centre-plate, and, being of wrought iron, did not break up like the cast-iron shot, which invariably fly into fragments, but flattened and stuck fast in the armor-plate, leaving one-third of its diameter outside. This effect arises from the ball squabbing out, from its own force, and becoming too large to pass through the hole made at the moment of impact. The diameter of the protruding portion measured thirteen and a half inches, that of the shot being ten inches. The effect of this missile was more destructive than that of the cast-iron shot. Keeping entire, it does all its work in damaging the target, whilst the latter expend part of their force in destroying themselves. Large pieces of the armor-plate were driven through the target, crushing the wood backing to shreds, bursting a great opening through the skin-plates, and completely smashing two more frames.

The discharge of this shot brought the destructive action of the 150-pounder to a close, for the gun burst in firing the fourth round;

the entire breech-end, weighing about seventeen hundred pounds, being blown off and carried one hundred and fifty feet behind.

In these experiments there was no denying that the gun had the best of it. The target was so fearfully mutilated, that if it had been a ship afloat, seeing the effect of only four shots, she would have been in as bad a predicament as a timber ship. The injury to the armor-plates and to the skin and frame, great as it was, was not so disastrous as the destruction of the fastenings. Three-fourths of the bolts which held the plates were gone. Of thirteen bolts, with which the centre-plate was secured, eleven were visibly broken. This damage to the fastenings arises from the plate, when struck, being bulged and driven into the wood backing, which affords no support, but yields to the blow; consequently, the butts buckle and start with a tremendous rebound from their bearings, tearing away the bolts. The three plates were dished, driven in at the centre, and curled up at the ends, one nine inches, and the other six or seven inches off from the wood backing.

It was further remarked, as a singular exception to the effects of former target experiments, that the armor-plates were not cracked at the bolt-holes. The explanation seems to be that the velocity and force of the projectile being so great as to penetrate the plates through and through, owing to the non-resistance of the wood backing, the shot did its work without causing the same amount of vibration as a shot at a lower velocity, on the same principle as a rifle-ball will pass through a pane of glass without cracking it. In former experiments, heavy shot at low velocities, and shell which produced only slight indentations in the iron, caused extensive cracks at the bolt-holes.

But notwithstanding the destruction of the target in these experiments, the result was claimed to be in favor of the system of defence, rather than that of the attack, and for two reasons: First, because the range was only two hundred yards, leaving an inference that at ten times that distance the shot would have failed to make any serious impression; and, second, because the destruction of the target was only effected by an effort which also destroyed the gun, a risk not to be thought of taking on shipboard.

The triumph of the defence was, however, of short duration; for the rupture of the Armstrong gun left the way open to other competitors, and a long-neglected piece, that had lain remote from view for several years, was suggested as deserving of an opportunity to try its powers. This was the so-called "Horsfall" gun — a wrought-iron smooth-bore piece of ordnance of thirteen-inch calibre, capable of carrying a ball of two hundred and eighty-six pounds, weighing twenty-two tons, and forged at the Mersey Steel and Iron Works, Liverpool. A target, representing part of the side of the armor-clad frigate *Warrior*, was used. It consisted of four-and-a-half-inch iron plates backed with eighteen inches of solid teak wood. The gun was loaded with a solid spherical shot, and a charge of seventy-five pounds of powder, and it was placed at the usual distance of two hundred yards from the target. The first shot was conclusive. It smashed through the entire target, and completely destroyed it for further experiments.

At a subsequent trial, however, when the range was increased from two hundred to eight hundred yards, it was found that the Horsfall gun could not be relied on for accuracy, and in fact could not be made to shoot straight at the latter distance. It was, consequently, for all practical purposes, considered to be a not very effective weapon.

Other trials of a still more important character succeeded. These were made with a Whitworth rifled breech-loading twelve-pounder field gun of four-inch bore, and a seventy-pounder rifled naval gun; the object of these trials being principally to test the penetration of Whitworth's flat-fronted hardened shells against armor-plates. Heretofore, all shells, of every description, fired against armor-plates of moderate thickness, failed to produce the least effect upon them. They have always broken like so many glass bottles, merely injuring the target with the flame of their explosion. So constant and invariable were these results that it was taken as an established fact that vessels coated with two-and-a-half-inch, or even two-inch armor-plates, would suffice to keep out any shell. As it is only shell which is dreaded in naval warfare, the Danish, Prussian, and Russian governments have each built gunboats covered with two-and-a-half-inch armor, confident that this is ample to protect their crews against all but solid shot. The experiments we are about to note, however, proved the complete fallacy of this theory. The first trial was made with the twelve-pounder, which sent a flat-fronted solid steel shot completely through an iron plate two and a half inches thick — no slight result, when we consider the lightness of the projectile. The next trial was made with shell, fired from the same rifled twelve-pounder against a target of two-inch armor-plate, with a backing of oak beams nearly a foot in thickness. The shell, with a bursting charge of one pound and fourteen ounces of powder, passed through both plate and backing, and buried itself in the earth beyond. The next, with a charge of one pound eleven ounces of powder, also passed through the plate, but burst in and shattered the timber backing behind. No fuse was employed with these shells, the heat generated by the concussion against the target being sufficient to ignite the bursting charge. These results, unexpected as they were, were far surpassed by those obtained with the seventy-pounder naval gun when fired with shell against a stronger target. This target was constructed of armor-plates bolted upon an oak frame nine inches thick, attached by a side framing to a back of oak four inches thick, coated over with two-inch wrought iron. The interval between the front and back frames was between two and three feet, the target being intended to represent the side of a ship. The shell weighed, when charged, seventy pounds, and contained two pounds and six ounces of powder. This, fired with a charge of only twelve pounds of powder, at the usual penetration range of two hundred yards, passed completely through the four-inch armor-plate and oak backing, and burst inside the frame, shattering it to pieces. This startling result, it should be remembered, was obtained, not by a gun of unusual weight or calibre, but with one weighing some fifteen hundred pounds less than the naval smooth-bore ninety-five-hundred-pound gun, and with a charge of powder of only one-sixth the weight of the projectile.

A week subsequent to the date of the above experiments, additional trials were made with a view of seeing whether the powers of Mr. Whitworth's gun and its flat-fronted steel shot would prove equally effective in the case of heavier ordnance, increased charges, and longer ranges. The gun used to settle these questions was a muzzle-loader, manufactured at Woolwich, on Sir W. Armstrong's wrought-iron coil principle, but with the hexagonal bore of Mr. Whitworth's mode of rifling. Its weight was seven tons and eight hundred pounds, its length about twelve feet, and its calibre a 120-pounder, though, in fact, capable of and quite equal to throwing shot of at least double that weight with perfect safety. It was placed on a platform, at a distance of six hundred yards from a target, twenty-one feet long by fifteen feet high, constructed of four-and-a-half-inch iron plates, eighteen inches of teak beams laid transversely, and an inner skin of iron five-eighths of an inch thick, supported by massive, upright angle-irons, at intervals of eighteen inches apart. The first experimental shot was fired with a charge of twenty-three pounds of powder and a solid hexagonal shot weighing one hundred and twenty-nine pounds, the piece being laid at half a degree of elevation. It struck the left centre of the target within an inch almost of the white spot at which it was aimed, and at the instant of the tremendous concussion of the metals a bright sheet of flame was emitted, almost as if a gun had been fired from the target in reply. This shot passed completely through the armor-plate, shattering the teak beyond into minute splinters, and fell full upon one of the massive vertical angle-irons we have mentioned, which it tore in halves as if it had been paper, sending its screw-bolts and rivets in all directions. The shot, however, did not pass *through* the target, but remained buried in the teak, with its flat head resting against the broken angle-iron. But the fracture it made was much worse than a mere penetration. It was a smash, not a hole, and the inner skin of the target was bulged and torn wide in many places, so that in the case of an actual vessel such a shot striking on the water-line would have made a leak which nothing could have stopped. As regarded the effect of these flat-fronted shot on iron ships, the experiment was conclusive. Such a missile against a wooden ship would have gone through both sides, making a clean hole and doing little damage; but the iron, without protecting, offered only sufficient resistance to make the fracture, if below the water-line, an irremediable mischief. The next experiment was with a live shell loaded with three pounds and eight ounces of powder. The total weight of this projectile was one hundred and thirty-one pounds, and it was fired at the same range and elevation with a twenty-five pound charge of powder. The effect of this shot, says the reporter of the London *Times*, astounded every one. The previous solid shot, at six hundred yards, was for Whitworth nothing very extraordinary; but to get a shell through the target at the same range was regarded as almost an impossibility. Yet the shell went completely through everything, bursting apparently when it encountered the last resistance of the inner skin, which the explosion blew completely away, lighting for a moment the timbers at the back which supported the target, and sending the bits of shell onward and over what, had it been the *Warrior*, would have been her main deck, and therefore right in the midst of her crew.

Than this experiment nothing could possibly have been more conclusive. Not only was the armor-plate pierced, but the piece opposed to the actual stroke of the flat-headed shell was driven through teak and inner lining, and, in truth, became another shot of some 30lbs. weight. In fact, this last shell might have destroyed the whole of one side of the target had the shell been only capable of containing an adequate bursting charge, — say 10 or 12lbs. of powder.

With these trials the record of English experimentation terminates, to be, no doubt, renewed again with some much thicker and stouter kind of target, which in its turn may perhaps gain a short-lived victory over the guns. Thus, from week to week, public opinion, and even the opinion of our scientific authorities, is kept vacillating between the comparative merits of the resistance of plate and the penetration of shot.

In commenting on the results attained to in England, the London *Times* says: — "They prove with certainty that, no matter what may be the thickness of the plates which iron-clad frigates can carry consistently with their safety as seagoing vessels, artillery can always be made to pierce them. Heavy shot and high velocity, in other words, heavy shot and heavy charges of powder, will smash through even 6-inch plates like glass, while we have yet to learn whether even 5-inch plates can be used on ships with safety to their sea-worthiness. As regards the ordnance to be used against iron-plating, all trials point to one conclusion, which is that the old smooth-bore gun has a more destructive effect on armor-plates than any rifled cannon, and that of all conspicuous rifled cannon Sir William Armstrong's is one of the least effective against these targets. The difference in the destructive effect of smooth-bore over rifled projectiles is exactly the difference between their initial velocity, or, in plain terms, the speed at which they travel after leaving the gun. With smooth-bores it is at the rate of some 1,700 feet per second, with rifled shot about 1,150 feet; and, as each of these projectiles has to be stopped dead in the fraction of a second by the iron target, it naturally follows that the one which is travelling fastest does the most mischief. If the trial, however, were made at ranges of 2,000 or 2,500 yards, the result would be precisely reversed, as the target at that distance would still find the rifled shot travelling its 1,150 feet per second, while that from the smooth-bore would have fallen off to 400 feet per second, or even less."

At the meeting of the British Association, 1862, Mr. W. Fairbairn (who was one of the government committee appointed to supervise the experiments above recorded) gave it as his opinion "that the victory thus far was with the guns, rather than the ships, and, indeed, that it would be difficult to construct ships with sufficient power to prevent their destruction by shells." To which the London *Times* replies as follows: — "Mr. Fairbairn's opinion is undoubtedly the general opinion, but practically it is incorrect. It is quite true that the recent experiments with large guns and heavy charges of powder have given a general or speculative kind of superiority to the attack over the defence, and it should also be acknowledged that by Mr.

Whitworth's system of construction the powers of even lighter pieces of ordnance have been surprisingly developed. But the great fact which remains, after all our trials, is that the *Warrior*, if she were in the middle of the Atlantic, would be absolutely impregnable; and we shall be doing the public a service, perhaps, if we recapitulate once more the practical results which, up to the present moment, have been actually established.

"The sides of the *Warrior* frigate, the model English ship, are constructed of 18 inches of solid timber plated externally with 4½ inches of iron, and backed internally with a skin of iron five-eighths of an inch thick. Altogether, therefore, there are upwards of 5 inches of iron and 18 of wood to be pierced by any projectile before the ship's decks can be reached. The 'Warrior target,' against which our experiments have been conducted, was so built up as to present a fac-simile of the *Warrior's* broadside, and consequently a gun which could pierce the target might be expected under similar conditions to pierce the *Warrior*. Now, it-is true that this feat has been accomplished, but it has been accomplished only under conditions so limited as to render the result of little importance, except as indicating what artillery may hereafter be made to do. The first gun which succeeded in the attempt was a piece specially constructed by Sir William Armstrong; but, though it destroyed the target, it also destroyed itself, being incapable of sustaining its own discharge. That specimen, therefore, we may dismiss for the present from our consideration. The Horsfall gun next drove its ponderous ball through the target, and without bursting, after which a gun combining in its make the Whitworth and Armstrong principles, but served with a Whitworth projectile, pierced the target not only with shot, but with shell. These are the achievements which have produced an impression in favor of guns as against ships; but that impression will be likely to disappear after the explanation which we now subjoin. The Armstrong gun was a 150-pounder, the Horsfall gun a 300-pounder, and the Whitworth a 150-pounder. We do not know the exact weight of the first of these pieces, but the second weighed 24 and the third upwards of seven tons. Now, according to our present ideas, a gun of 95 hundred-weight, or less than five tons, is the heaviest that can be worked with success, or even safety, on board a floating vessel; so that not one of the guns which pierced the Warrior target can be considered as a ship gun, and it follows necessarily that against all ships whatever the *Warrior* is secure. As any gun capable of piercing her sides must be mounted on *terra firma*, so long as she keeps at sea she cannot be touched at all.

"Nor is this the only limit to the efficiency claimed for the gun. The power of the Armstrong cannon was demonstrated only at 200 yards' distance. The Horsfall piece was tried with three times that range, but at that distance it was found unequal to straight shooting. The Whitworth gun did remain effective at 600 yards, but beyond that range its powers have not yet been proved. We arrive, therefore, at the conclusion that a gun to be effective against the *Warrior* must not only have a fixed battery to carry it, but must get the ship within 600 yards of its muzzle. How is this to be accomplished when the ship is movable and the gun is not? In point of fact, we come to this — that if a shore fort is mounted with the most powerful gun yet discovered, and the *Warrior* chooses to run close under its walls, she may get her sides knocked in, but that is all. If she keeps at merely 700 yards' distance, she is, as far as we know at present, quite safe, whereas it is perfectly well understood that at twice or thrice that range she could pitch her own shells into any fortress or arsenal. This leaves the case of ships against guns in no bad position for the former.

"It seems to have been forgotten that ships encounter ships as well as forts, and that in the former contest the guns have as yet been beaten hollow by the best models of armor. No ship's gun yet produced would be effective against a first-rate iron-cased ship. Mr. Whitworth has made the greatest progress in this direction. His 70-pounder might really be carried in a ship's battery, but then his 70-pounder has never pierced the Warrior target. It has only pierced a target of four inches of wood plated with four inches of iron. It is a most valuable weapon, for it would be an effective arm against all imperfectly cased vessels, or, in other words, against most of the armored ships now afloat; but there are ships that can keep out its shot. All through the contest, in short, there runs this dilemma, that a gun meant to pierce the *Warrior's* sides is either too light for its purpose or too heavy to be carried at all. Of course, it is not to be assumed that the carrying powers of ships may not be extended. It is possible, perhaps probable, that before long we may have a vessel produced which will carry a seven-ton gun, but that is not the case at present, and we must take things as they are, not as they may be. As matters now stand, it is only a shore gun that can pierce the *Warrior's* sides, and that only within a very short range.

"We have no wish to conceal our opinion of the capabilities of ordnance in the hands of able inventors. We think it not at all unlikely that Mr. Whitworth's last gun may be found effective when tried at a longer range, and perhaps equal efficiency may some day be obtained from a more portable piece. But these are not the questions now before us. We have been dealing solely with results actually established, and these, though they demonstrate undoubtedly the resources of artillery science, do certainly not prove, as a general proposition, that guns have won the day against ships. Taking a ship's battery against a ship's armor, we find the superiority on the side of the latter, for we have frigates actually afloat which can resist any gun yet tried of proportions available for naval service. That is the present state of the case. It may be altered to-morrow, but it leaves our first-rate ironsides in a very fair position to-day."

Capt. Dahlgren's Views. — Capt. Dahlgren, the well-known American authority on naval ordnance, etc., in a recent report to the Secretary of the Navy, December, 1862, thus expresses his views in regard to the construction of armor-plated vessels, and their defensive qualities: —

After referring to the results of the English experiments above given, he says: — "It would be unwise to rush to the conclusion that armor is needless because the most powerful ordnance should, under skilful guidance, be able to pierce it. For even against such cannon a ship may delay the conclusive difficulty long enough to make its own guns of avail; and, when opposed to any but these heaviest pieces, will still be in effect impregnable. The case of the Monitor and Merrimac affords an illustration. No one supposes that either of these vessels could have escaped serious injury if subjected to a course of target firing from the most recent and powerful descriptions of ordnance; yet they sustained for four hours the utmost effort of each other's batteries. The Monitor was hardly more than scarred by the fire of the very guns which, on the preceding day, had, in a fourth of the time, acted most destructively on the hulls and crews of two fine wooden frigates."

With regard to the opinion which prevails in England, that solid plating is superior for resistance to several plates combined, Capt. Dahlgren says: — "Practice in the United States proves that several plates made into one are preferable, on many accounts, to one solid plate, and would be so altogether if it were not for the increased number of bolts that become requisite, and are the weakness of all such plating. Indeed, even with this disadvantage, it remains to be seen whether, by any process, a very thick solid plate can be made equal in its texture to the thinner plates. For in every instance where I have seen a solid plate pierced by a shot, the imperfection at the welds has been made manifest by their separation, although externally none such could be perceived."

Capt. Dahlgren also states that the results of his experiments favor the use of "cast" rather than of "wrought" iron shot. "The cast-iron shot does break, and the wrought-iron is only crushed; but while the latter lodges in the four-and-one-half inch plate, the former (both being of eleven inches) passes completely through the plate, and nearly through the wooden backing of twenty inches, making a larger hole, and badly cracking the plate."

"The operations that have been conducted in the United States," continues the writer, "with reference to the power of different cannon and projectiles, as well as the resistance of iron plating, have been so far satisfactory that the results derived have been consistent. Still they are liable to such qualification as may be properly due to practice upon targets only, and in some sense favor the defence, because many sources of weakness which are unavoidable in the extensive structure of a ship are undisclosed in the strong, new, and well-knit target, but will appear when vessels are subjected to fire and to the wear and tear of time and service, especially at sea. So long as the ponderous armor is merely attached to the ship, and is not made to contribute to the strength of the fabric, but severely taxes that strength, so long will there be involved a serious element of deterioration, which will after a while impair the general capacity for endurance, and in the end unfit the ship for battle. In this respect, as in many others, the turret class are to be excepted from much of the preceding remark, and are probably of greater and more certain endurance under severe fire than the ordinary plated vessel. So far, they are likely to find the most fitting sphere for their peculiar powers in the less troubled waters of harbors and rivers; though the ability that has devised them may also be able to give a wider scope to their usefulness."

Armament of Iron-Clad Vessels. — Capt. Dahlgren also states his views respecting the armaments best adapted to meet the wants of iron-clad vessels, as follows: — "This question would be reduced to very narrow limits, were it possible to decide intelligently upon the claims of smooth and rifled cannon. But the obviously unperfected condition of the latter interposes an obstacle to a fair consideration of its merits, which the ingenuity of very clever men has long been exerted upon without complete success. 1. The rifled shot when moving correctly is the more accurate to first graze, though not materially so, at moderate distances, — say thirteen hundred to fifteen hundred yards. Beyond a mile, its advantage in this respect is very marked. 2. But after encountering any object, its deflections are of the most erratic description, and it generally tumbles over so as to nullify its force, and render its subsequent direction beyond conjecture. Wherefore, the rifled shot has no capacity for ricochet, which is one of the most certain modes of operating with the round projectiles in naval service, and is of the utmost importance because so many shot fall short and strike the water first. 3. The rifle shot has greater penetration than the round, but much less concussive power. At the present time, considerable improvements are required to give regularity and certainty to the distinctive qualities of the rifled shot; and there is no little trouble experienced also with the stripping of soft metal from them, and the imperfect operation of their fuses. These, being defects rather of detail, will no doubt be ultimately got rid of. Meanwhile, the rifle gun is gradually making its way into the service, and becoming better understood by soldiers and sailors.

"A glance at the forms which this arm has assumed in different countries shows the great variety of solutions that the problem is capable of, and may possibly indicate some difficulty in uniting all the qualities desired in one piece. The greatest diversity will be noticed, for instance, between the device of Armstrong and of Whitworth, and the *Canon Rayé* of the French. They differ totally in the material and construction of the cannon, projectile, and fuse. And while no one service is entirely satisfied with its own arm, it seems to find nothing better in that of another.

"If, in battering an iron-clad, penetration only shall be the paramount consideration, and other effects merely incidental, the rifle cannon must be selected. But if the concussion and shattering of the plate and its backing be preferred, with such penetration as might be consequent thereon, then the heavy, swift, round projectile will supply the blow best adapted to such work. So long as the present mode of plating continues, there can be little doubt that it will be most effectively attacked by cracking and bending the iron, starting the bolts, stripping off the armor, and breaking away large portions of the wooden structure within. And to this mode of action I feel more inclined, after witnessing its effects upon a number of targets plated with solid iron, or with thin plates bolted into one, the direction of the fire being perpendicular or oblique.

"The number of guns being very much reduced, of necessity, in iron-clads, particularly in the turrets, which will only accommodate a pair of them, it would naturally be supposed that the weight of broadside would also be limited. But the very large calibres that are likely to be adopted will so far compensate for the loss in number, that the diminution of power will not be important, and, in some instances, there will be a gain in weight of projectile. Thus, the Roanoke, which originally threw 1,424 pounds from her broadside, and is now converted into a turret ship, will throw 2,700 pounds at an object abeam, when fully armed, and 900 pounds ahead or astern. There must be, however, a material reduction in the celerity of fire with guns and projectiles so large as the eleven-inch, whatever may be the mechanical appliances which may be brought to assist. An eleven-inch gun, with a well-disciplined crew, can be fired once a minute; but there must be much improvement in any mode now suggested before a fifteen-inch gun can be fired once in triple that time. As a certain capacity for repetition is essential to the general power of a battery, there is thus involved a disadvantage which can only be compensated to any extent by the great concentration of effect in the individual projectiles. For it may be conceived that the effects of shells of three hundred and thirty pounds, and shot of four hundred and fifty pounds, will be damaging beyond any experience in former batteries. What may be the power of such ordnance against iron-cased ships, comparative or absolute, remains to be ascertained. This, as well as the piece itself, is yet but an experiment."

In conclusion, Capt. Dahlgren expresses his opinion, "that, as the case now stands, the offence has decidedly the advantage, and that no seagoing ship can be considered as impregnable to artillery."

Thoughts concerning the Unhealthiness of Iron-Clad Vessels. — The London *Lancet* makes the following suggestions respecting the unhealthiness of iron-clad vessels. An iron-cased ship may afford greater protection to her crew from shot and shell than a wooden ship, but it has been overlooked that, to whatever extent this protection has been obtained, to a like extent the vessel has been made less fit for habitation. It has been forgotten, in short, that shot-proof ships might require for their due working disease-proof sailors. Experience has again and again shown that, in time of war, for one man lost from the casualties of actual contention, several have been needlessly lost from disease. The conditions which have given rise to this additional, most wasteful, and most unnecessary expenditure of life unhappily exist to almost as great an extent in peace as in war, and the chief of these conditions has been clearly set forth by Lord Paget, secretary to the British board of admiralty, in a recent debate in Parliament. He said, " Everybody who has been on board ship in the lower deck will know that the atmosphere is sufficiently bad to provoke almost any kind of disease, especially phthisis and fevers, as has been shown by the returns from British fleets on tropical or semi-tropical stations." This was said of wooden ships of war; but when we reflect that in armor-plated ships the portholes are largely diminished in number and greatly lessened in size, and that, the more effectually to strengthen the walls of the vessel and prevent the intrusion of shot or shell, no aperture of communication with the interior is permitted to exist which can possibly be done away with, we are justified in concluding that the state of the between-decks, referred to by Lord C. Paget, will in these ships be greatly intensified. When, moreover, we remember that, from the character of these vessels, and as shown by experiment, the temperature of the between-decks is higher than in vessels of any other class,—that in hot weather the iron walls suck up heat with the avidity of a salamander,—and that it is far from improbable that the practicability of keeping the "bilges" sweet has been forgotten in the progress of building (as in the case of the Warrior),—we may also reasonably infer that the principal conditions which concur in increasing the foulness of the between-decks in wooden are also found in a higher degree in armor-plated vessels. Hence we are led to the ultimate conclusion that these latter ships promise to be much more destructive to their crews than any enemy; at any rate, to estimate the power of destruction by their offensive capabilities alone is a delusion.

The truth is, that, until the subject of ventilation enters as systematically into the scientific estimate of the construction of a ship as speed and fighting qualities, the problem of ventilation will never be rightly solved, the needless waste of life which now exists in our navy in peace as well as war put an end to, and the chances of a catastrophe amongst the crew of our ironsides by the ravages of fever diminished. What would be the fate of the sailors of the Warrior or Defence if typhus or yellow fever broke out on board?—to say nothing of the chances of both officers and men being ignominiously suffocated in their iron-cased domicil, under the blazing sun of the torrid zone, after the fashion of certain doughty knights of old.

French Results.—Of the results and inferences arrived at by the French authorities touching the construction and armament of iron-clad vessels, the world knows but little beyond what has been necessarily disclosed to the observer. It is believed, however, that they have no faith in the Armstrong gun, or in any breech-loading gun whatever; and, also, that they reject the plan, followed to some extent in England, of plating iron upon iron, but plate iron upon wood.

The following is the reported strength of the French iron-clad navy: Ten iron-cased floating batteries constructed during the Crimean war; two floating batteries of fourteen guns each, which have a speed of six and one-half knots per hour, and are covered with four-and-one-half-inch iron plates; four iron-cased frigates afloat, namely, the *La Gloire*, *Normandie*, *Invincible*, and *Couronne*, each of which has engines of nine hundred horse-power, and a plating of four-and-three-fourths-inch plates; two armor-clad rams, which have engines of one thousand horse-power; from ten to fifteen large iron-cased frigates of the *La Gloire* class on the stocks; and about the same number of armor-clad batteries in preparation, which are mainly intended for harbor defences.

A recent writer in the London *Times*, who professes to be posted, states that "it is extremely doubtful whether any naval guns at present introduced into the armament of iron ships could inflict any serious damage on the French frigates *La Gloire* and the *Normandie*; and it is certain that the French have introduced a gun which will throw a flat-headed shot through four-and-one-half-inch plates with a thick timber backing. The armament of the *Gloire* itself consists of guns (called *pièces de* 30) which, with a charge of rather more than fifteen pounds of powder, throw a ninety-pound shot through twelve centimetres of iron plating at forty metres. But the French artillerists have accomplished far more than this. As long ago as August, 1861, they constructed a rifled gun which, with a charge of twenty-five pounds of powder, threw a projectile through the iron-plated target at one thousand metres; and, although this gun is not yet in common use in the French service, several specimens of it have been manufactured, and the experiments have been carried on in the present year with increasing success." The writer also asserts that the French model gun is not unlike the weapons with which Mr. Whitworth has obtained the startling results detailed in the preceding part of this article.

English Iron-clad Navy. — The English have four iron-cased frigates completed and in service, namely, the *Warrior*, *Black Prince*, *Defence* and *Resistance*. The two former are the most formidable armor-clad frigates afloat; have engines of twelve hundred and fifty nominal horse-power, and carry forty guns; the two latter have engines of six hundred horse-power, and carry eighteen guns — Armstrong one-hundred-pounder rifled, and sixty-eight-pounder smoothbores. Besides these, the English have seventeen other iron-clads in the course of completion, four of which are larger than the *Warrior*, and will be plated from stem to stern with five-and-one-half-inch plates. The English admiralty are also transforming a number of thirty-six-gun frigates into iron-clad sloops, by cutting them down and attaching plates only a little above and below the load line, and the midship part of the vessel containing the guns.

New Austrian Guns. — The improved cannons adopted by the Austrian government are formed from a new alloy, called *Aich* metal, from its inventor. It is composed of copper six hundred parts, zinc three hundred and eighty-two, iron eighteen. Its tenacity is said to be excessive; it is easily forged and bored, and when cold may be bent considerably without breaking; its resistance, it is also stated, is far greater than that of iron of the best quality.

Breech-Loaders vs. Muzzle-Loaders. — Some interesting experiments to test the comparative efficiency of "breech" and "muzzle" loading field artillery were made in England, Oct., 1862, under government direction. The muzzle-loading guns were four in number, of Whitworth's pattern, brass twelve-pounders, rifled. The breech-loaders were of Armstrong's pattern, iron twelve-pounders, with all the latest improvements. The trials began by firing at a floating target distant five hundred yards. As the shot fell in the sea, no very close comparison could be made as to the accuracy of the respective hits, but both at the five hundred yards range, and afterward at the twelve hundred yards, the shot from the Whitworth was the first to carry away the flag aimed at, and it was generally conceded that at both ranges this gun fired closer to the mark than the Armstrong. Both guns were then tried with shell, the Armstrong firing compound percussion shells, and the Whitworth firing a new kind of shrapnel. It was observed that a considerable number of the Armstrong shells burst in the air before reaching the mark, and, of course, without effect; but the Whitworth shell, being used with a time-fuse, which is ignited in front like the old shell, was found to be more regular and effective in its action.

But perhaps the most interesting part of the experiments was a comparison made between the two different kinds of ordnance as to rapidity of fire. It has always been held that the one great advantage of the breech-loader was its superiority in handiness and quick firing. The result of this trial does not, however, confirm this opinion. The artillery-men were ordered to fire twenty rounds from each gun as rapidly as they could be served. The Whitworth gun finished the twenty rounds first, completing the task in thirteen minutes; the Armstrong followed two and a half minutes later. This superiority was attributed to the simplicity of the loading and serving the Whitworth gun, the drill being, in fact, precisely the same as in working one of the old smooth-bore guns; whereas the Armstrong drill requires three or four extra movements. All the guns were further tried by firing from each one hundred consecutive rounds. The Armstrongs were fired with lubricating wads, and were also washed out and had their breech pieces changed as often as they became heated so as to be unsafe; the Whitworths all completed their one hundred rounds without being washed out at all, and without using any lubricating wads. It was remarked, too, that the loading was as easy at the last round as at the first.

New Rockets. — Lieut. Samuel Parlby, of the Bengal Artillery, has recently published a paper on the use of rockets for war purposes, in which he says, that it is perfectly practicable to produce rockets of one thousand pounds weight, which can be thrown with equal exactness as shells from mortars. One of these falling upon the deck of a ship, he claims, would immediately destroy it.

American Iron-clad Vessels. — During the past year, the United States Government, encouraged by the success of the *Monitor*, built and modeled by Capt. Ericsson in 1861, have caused to be constructed *nine* additional iron-clad vessels for use on the Atlantic coast; all of them being built on substantially the same plan as the Monitor, but rendered more formidable both for attack and defence. The following are the details of the construction of one of the largest of these vessels, viz., the *Weehawken:* — Extreme length of armor two hundred feet; extreme length on water-line one hundred and ninety feet; extreme breadth over armor forty-six feet; breadth of moulded beam thirty-seven feet. The bulwark armor-timbers are oak, seventeen inches in thickness. The plating of the bulwarks is five inches in thickness, in layers of one-inch plates, planed at the edges and breaking joints. This armor extends three and one-half feet below the water-line, and projects three feet eight inches beyond the hull proper. The deck beams are of oak, twelve inches thick, covered with pine planking seven inches thick, and over these two courses of half-inch plates are fastened.

The Weehawken is provided with one revolving turret of twenty-one feet internal diameter, nine feet height, and covered with eleven courses of one-inch wrought-iron plates. This turret rests on a flat ring of gun-metal, and revolves on a central shaft one foot in diameter. The armament of the turret is two fifteen-inch Dahlgren guns, manufactured at the Fort Pitt foundry, Pittsburg, Pa. The pilot-house is round like the gun turret, and in this respect is an improvement over the square pilot-house first built for the *Monitor*. The smoke-pipe is shot-proof, eight feet in height, six inches in thickness, telescopic in shape, and covered on the top with a grating to keep out shells. The vessel is propelled by a pair of horizontal engines, each having a cylinder forty inches in diameter, with a stroke of twenty-two inches. Ventilating blowers are used, and the cold air is drawn through the top of the turret.

The fifteen-inch guns carried in the turret of the Weehawken, and upon other of her companion vessels, weigh nineteen tons each, and are the largest pieces of ordnance ever tried on shipboard. They are easily worked, however, through the aid of newly devised machinery, by three men; and are fired through a muzzle box from within and through the port-hole, and not, as usual, from the exterior, — the port-hole being only seventeen inches in diameter, while the face of the muzzle of the gun is twenty-nine inches.

Of other iron-clad vessels, one called the *Keokuk*, designed and built for the U. S. Government by Mr. C. W. Whitney, of New York City, differs essentially in its construction from any of the above referred to constructions. She is one hundred and fifty-nine feet long, thirty-six feet three inches beam, and has thirteen feet six inches depth of hold. There are two fixed turrets and a short smoke-pipe visible above deck; these alone break the smooth surface which everywhere slopes to the water's edge. The side armor extends four feet below the fighting draft, which will be about eight feet six inches, and for a portion of the length, amidships, presents an angle of thirty-seven degrees to the horizon. This inclined armor runs up to the main deck on each side, which is but little wider than the turrets. The bow and stern of the Keokuk round away to the water, and present the same appearance to the eye that a wasp's body would immersed. The deck beams are a continuation of the ship's ribs, which are of iron, four inches deep by one inch thick, placed eighteen inches apart. Over these ribs a half-inch plate is laid, and that relaid again with a five-inch wooden deck; this latter is caulked water-tight, and then armed with two half-inch iron plates, somewhat similar to the Ericsson Monitors. The casemated portion of the vessel, five and three-fourths inches thick, is laid with iron four inches deep by one inch thick, placed one inch apart, the interstices being filled in with yellow pine. The remaining one and three-fourths inches are made up by the outside sheets. This armor is fastened on with countersunk bolts one and one-eighth inches in diameter and twelve inches apart, secured inside with strong, six-sided nuts. The deck has only seven-eighth bolts through it.

The turrets, two in number, are stationary, and mount one eleven-inch gun each. They are fourteen feet in diameter at the top, and twenty feet at the base, extending seven feet above the deck, and twenty inches below it; and upon a platform constructed at that line the guns are mounted. The turrets proper consist of wrought-iron skeletons, made of flat iron, five inches deep by one inch thick, placed edgewise, fifteen inches apart, and secured to a half-inch sheet by four wrought-iron clamps four inches deep by one inch thick. The fifteen-inch spaces remaining inside are filled up with wood, and afterward covered with a thin sheet-iron lining, to make a smooth finish; outside of the turret-skin, half-inch plate, the protection is the same as that of the casemates. Each turret has its own shot, shell, and powder-magazine, communicating from the deck, just underneath the tower, by hatches. In the after-end of the forward turret is the pilot-house, which is two feet higher than the main structure.

The turret gun decks, twenty inches below the main deck, consist of a circular iron frame six inches deep by three-quarters of an inch thick, supported by twelve wrought-iron beams two and a half inches in diameter. This frame is further crossed at regular intervals by fourteen wrought-iron beams, also six inches deep and three quarters of an inch thick. At right angles with the latter a strong box girder, twelve inches by eighteen inches across the angles, is riveted to the circular frame, being strengthened in the middle by a heavy wrought-iron column five inches thick. Upon the top of the fourteen beams, previously mentioned, a wooden deck five inches thick is laid, to which the gunways are made fast. In the centre of the turret the gun is pivoted; three ports are made for it in the turret — two broadside, and one aft or forward, as the case may be. A lateral range of eight degrees and a vertical one of ten degrees can be obtained for the missile. From the lower deck, inside the turrets, two doors permit communication with the forecastle, and also the engine-room and officers' quarters. There are two water-tight compartments in the vessel, one fore-and-aft, to which access is had by the usual man-holes; these can be filled with water, if desirable, in a short time, and will, it is calculated, settle the ship one foot. The forecastle is large and roomy, so much so that one hundred men can swing their hammocks in it. Alongside of the vessel, just behind the casemates, are the coal-bunkers, and immediately enclosed by them and two fore-and-aft bulkheads are the steam boilers. Before a shot can strike the latter it must pass through the inclined side, the coal, and also the two stiff bulkheads or partitions just mentioned; they are, therefore, very fully protected.

The *Keokuk* is propelled by engines of five hundred horse power, which drive a true screw under each quarter of the vessel of about seven feet diameter.

Contracts have also been entered into between the United States Government and Captain Ericsson for the construction of two iron-plated vessels of a more formidable character than any hitherto essayed by him. They will bear a general resemblance to the *Monitor*, with such modifications as have been suggested by experience. One of them is to be three hundred and twenty feet in length, and the other three hundred and forty-one, with fifty feet beam. The vertical sides are six feet in depth, and are to be protected with iron armor-plating ten and a half inches in thickness, backed with four feet of solid oak.

The turrets are to be absolutely invulnerable. The contract provides that they shall be two feet in thickness, but the contractor has leave to reduce the thickness, provided he can satisfy the navy department that less will be sufficient. The engines are to be of sufficient size and power to give an average guaranteed speed of sixteen knots per hour. The armament will consist of fifteen-inch guns.

But it is as *rams* that these two new vessels are expected to be most efficient. Where the plates of the sides meet at the bow they form an iron wedge, twenty-one inches thick at the base, and terminating in a sharp edge. This wedge is sustained by the plates behind it, ten and a half inches in thickness, six feet in depth, and extending the whole length of the vessel, forming the most powerful butting instrument that it is possible to conceive of. Captain Ericsson says, "It will split an iceberg."

Some interesting additions to our knowledge respecting the resistance of iron plates to projectiles have been gained from the experience of iron-clad vessels upon western rivers of the United States. In the construction of the *Essex*, the flag-ship of Commodore Porter, a peculiarly prepared lining of India-rubber was placed between the one-inch iron plates used and the wooden backing. The efficacy of this expedient was demonstrated on the 22d of July, 1862, when the Essex, under the batteries of Vicksburg, sustained for two hours and a half a fire of seventy heavy guns in battery, twenty field-pieces, and three heavy guns afloat. So rapid and terrific was the fire that the commodore, in his official report, states "that for half an hour the hull of the ship was completely enveloped in the heavy jets of water thrown over her by the enemy's shot, shell, and balls." At one time this cannonading was at so short a range that he says "the flashes of the enemy's guns through my port-holes drove my men from the guns." The results of this fire from batteries not one hundred feet off is thus described in the official report:—"A heavy ten-inch shot from the nearest battery struck my forward casemate about four feet from the deck, but fortunately did not penetrate. A rifle seven-and-a-half-inch shot from the same battery struck the casemate about nine feet from the deck; it penetrated the iron, but did not get through, although so severe was the blow that it started a four-inch plank, two inches thick and eighteen feet long, on the inside. A conical shell struck the casemate on the port side, also, as we were rounding, penetrated the three-quarter-inch iron, and came half way through the wooden side; it exploded through, killing one man and slightly wounding three."

During the heavy cannonading most of the shot glanced from the sides of the Essex, but "during that time this vessel was heavily struck forty-two times and only penetrated twice." This penetration was by the rifle seven-and-a-half-inch shot and the conical shell above described.

James's rifled Projectile for Battering Purposes.—The bombardment of Fort Pulaski demonstrated the extraordinary efficiency of James's projectile for battering down stone-work. The New York *Times* correspondent, describing its effects, says:—"The whole side of the casemate was shot away. The Parrott guns had been comparatively harmless, the work being done almost entirely by the James projectile." Another correspondent, writing from the ruins of Pulaski to the New York *Tribune*, says:—"The guns which contributed most to the breaching of the wall were those which carried the James projectile. That was the testimony of the officers of the fort; and in the thickest of the ruins it was always these shot which we found most abundant." A private letter, written by an officer, says, "This shot bored through a massive brick wall, and ground up the material like powder." Gen. Gilmore, the engineer officer in charge of the siege operations, in his official report makes especial mention of James's projectile, and says, "No better piece for breaching can be desired than the forty-two pounder James."

New American Guns. — While the English navy is being armed with guns of very complex structure, those of the American navy have for several years been growing more and more simple. At first the plan of having ornaments cast upon them was abandoned; then the enlargements in the form of bands around the muzzle and other parts were dispensed with; and now, as the last possible step in this direction, they are cast without trunnions, making the cannon a smooth lump of cast iron, without any ridge, corner or projection upon it. This modification is the last improvement introduced by Capt. Dahlgren. He forms the trunnions of gun-metal, cast in connection with a strap passing around the breech of the cannon, and secured by a hoop of the same material passing around the cannon near the trunnions.

It has long been known that corners or angles in the surface of cast iron rendered it much more liable to break. The rollers of rolling-mills are now turned with a curve at the shoulder of the journal, it having been found that they were apt to break at this point; and the introduction of a curve occupying only half an inch in the length of the roller is said to increase the strength about thirty per cent.

The liability to break at the corners is greatest when the metal is subjected to blows or concussions, and is especially marked in cannon. This has been the reason for dispensing with ornaments and projecting rings, and for several years our service-guns have been cast with no angles except those at the junction of the barrel with the trunnions. It being observed, however, that the guns were very apt to fail at this point, Capt. Dahlgren has devised the above plan of overcoming the difficulty. — *Scientific American.*

Snyder's Bullet Machine. — The product of these celebrated bullet machines, invented by A. B. Snyder, and now used exclusively by the United States Government in their arsenals, appears from official figures to have reached the following extraordinary quantities: — During a period of nineteen months, or from May 1st, 1861, to December 1st, 1862, they produced one hundred million, one hundred and nine thousand (100,109,000) elongated bullets, weighing 5,810 tons. Snyder's machine is one of the most perfect pieces of mechanism ever produced by American ingenuity.

Plan for Firing Guns under Water. — J. P. Woodbury of Boston has devised the following plan for firing cannon under water. The guns are to be of the usual shape, but much longer than common, and can be cast to discharge any projectile now in use. When ready for action, a tin cylindrical case is fitted closely at the muzzle of the gun, rendering the chamber air-tight and preventing the entrance of water. When fired, the charge attains its full velocity before reaching the canister, and an effective shot may be made at the distance of two or three hundred feet. The cannon is fixed into a stuffing-box similar to that of the piston of a steam-engine, and an automatic port-hole opens and shuts as the gun is run out or withdrawn. It is expected that very little water will be shipped as the piece is drawn in. The gun being breech-loading, the water which enters the muzzle is easily disposed of, and it is claimed by Mr. Woodbury that it can be fired again in the space of three to five minutes. In some experiments made at East Boston, a twelve-pounder was fired under water at a target made of spruce plank, crossed at right angles, and heavily bolted and braced, and placed at a distance of ten or twelve feet. The target was effectually penetrated.

Doremus's Compressed Gunpowder. — The following is an abstract of the specification of the patent granted for this invention, which has been adopted by the U. S. Government, and, after most careful experimentation, also by the French (see *Annual of Scientific Discovery*, 1862, p. 97): —

The nature of the invention consists in taking granulated dry powder, and placing a certain quantity to form a charge in a mould of a cylindrical form, then submitting it to pressure under a piston, by which pressure the dry powder becomes solid, and may be removed from the mould and handled freely. Another part of the invention consists in submitting two or more layers of powder in one cartridge to different degrees of pressure, to produce what is called an "accelerating cartridge." The method of manufacturing these cartridges is as follows: — Moulds of the requisite size and form are provided with suitable movable pistons to fit into them. To make a cartridge for a six-pounder gun, in which one and a quarter pounds of powder constitutes a charge, this amount of granular dry powder is placed in a cylindrical smooth brass mould, of such a diameter as coincides with the bore of the gun, so that the cartridge will enter it. When the powder is introduced a piston is placed upon it in the mould, and pressure by a hydraulic or screw press is applied until the powder has been condensed by a power equivalent to fifteen tons weight. The piston is then taken out, and the compressed powder discharged, in the form of a cylindrical cake, which may be handled without breaking. In this form the granular condition of the powder is still maintained. Other sizes of cartridges are formed in a similar manner.

To make an accelerating cartridge, the method described is as follows for three degrees of combustibility: — The powder is divided into three portions: one of these is first placed in the mould and submitted to a pressure of twenty-five tons; the second portion is then poured in and subjected to a pressure of twenty tons, and finally to the last portion there is applied a pressure of fifteen tons. The whole of the powder placed in the mould and thus treated is now compacted into one mass or cake, having three distinct strata of different degrees of combustibility. That which has received the greatest amount of pressure consumes less rapidly than the other portions. The rapidity of ignition and burning of each is in proportion to the degree of pressure to which it has been subjected. The requisite pressure for such cartridges can only be ascertained by experiment.

Powder in cartridges made in this manner by solidifying will resist the action of moisture for a longer period than when in loose grains. It will be also understood that these cartridges are cylindrical cakes of powder, without paper or any other usual covering; and as the flannel bags in which the ordinary charges for artillery are contained are the chief causes of the fouling of the gun, the use of uncovered solid cartridges obviously presents great advantages. Such cartridges may be further rendered water-proof by coating them with a solution of collodion.

MECHANICAL PROPERTIES OF PROJECTILES.

In a paper on the above subject presented to the British Association, 1862, by Mr. W. Fairbairn, the author commenced by stating that in the investigations which had taken place with regard to projectiles and armor-plated ships, one great difficulty that had arisen was to get plates of sufficient thickness, and vessels of sufficient tonnage to carry those plates. It appeared that they were limited to plates of five inches in thickness; with plates heavier than that a ship would not be what was technically called "lively." He had attended the experiments instituted by the government at Shoeburyness from the commencement, and they had reference to the force of impact. He would state the results. The first series of experiments had reference to the quality of the plates and the properties of the iron best calculated to resist impact. There were three qualities required: — first, that the iron should not be crystalline, but, second, that it should be of great tenacity and ductility, and, third, that it should be very fibrous. Mr. Fairbairn produced specimens of spherical and flat-ended shot, and proceeded to give the statical resistance of each.

The mean statical resistance to crushing of the two flat-ended specimens of cast iron is 55.32 tons per square inch. The mean resistance of the two round-ended specimens is 26.87 tons per square inch. The ratio of resistance, therefore, of short columns of cast iron with two flat ends to that of columns with one flat and one round end is as 55.32 to 26.87, or as 2.05 to 1. Applying this same rule to the steel specimens, it would appear that the flat-ended shot would have sustained a pressure of 180 tons per square inch before fracture. In the experiment it actually sustained 120 tons per square inch without injury, excepting a small permanent set. In the experiments with cast iron the mean compression per unit of length of the flat-ended specimens was .0665, and of the round-ended .1305. The ratio of the compression of the round-ended to the flat-ended was, therefore, as 1.96 : 1, or nearly in the inverse ratio of the statical crushing pressures. Applying this law to the case of the steel flat-ended specimen, we may conclude that the compression before fracture would have been only .058 per unit of length. The determination of the statical crushing pressure of the flat-ended steel shot as 180 tons per square inch and its compression as .058, is important, on account of the extensive employment of shot of this material, size, and form in the experiments at Shoeburyness. In the case of the lead specimens, the compression with equal weights was the same, whether the specimen were at first round-ended or flat-ended. This is accounted for by the extreme ductility of the metal and the great amount of compression sustained. In regard to the wrought-iron specimens, it may be observed that no definite result is arrived at, except the enormous statical pressure they sustain, equivalent to 78 tons per square inch of original area, and the large permanent set they then exhibit: —

	Statical Resistance in tons per square inch.	Dynamical Resistance in foot lb. per square inch.
Cast iron, flat-ended,	55.32	776.8
Cast iron, round-ended,	26.87	821.9
Steel, round-ended,	90.46	2,515.0

In the experiments on the wrought-iron specimens, the flat-ended steel specimen, and the lead specimen, no definite conclusion was arrived at, the material being more or less compressed without any fracture ensuing. Hence it is difficult to draw conclusions from these results, but the great amount of work expended in compressing the wrought-iron specimens amounted in one case to 4,340 foot lbs., or nearly twice as much as was required to fracture the round-ended specimen of steel. On the other hand, the low statical resistance of lead corresponds with a dynamical resistance almost equally low. The work required to crush similar specimens of cast iron is nearly the same whether the ends be rounded or not, the round-ended requiring rather more work to be expended than those with flat ends. The mean resistance of the specimens of cast iron is 800 foot lbs. per square inch; that of the specimen of steel is 2,515, or rather more than three times as much. The conditions which would appear to be desirable in projectiles, in order that the greatest amount of work may be expended on the armor-plate, are, — 1. Very high statical resistance to rupture by compression. In this respect wrought iron and steel are both superior to cast iron; in fact, the statical resistance of steel is more than three times and that of wrought iron more than two and a half times that of cast iron. Lead is inferior to all the other materials experimented upon. 2. Resistance to change of form under great pressures. In this respect hardened steel is superior to wrought iron. Cast iron is inferior to both. The shot which would effect the greatest damage to a plate would be one of adamant, incapable of change of form. Such a shot would yield up the whole of its *vis viva* to the plate struck; and, so far as experiment yet proves, those projectiles which approach nearest to this condition are the most effective.

Mr. Fairbairn stated that steel shots might be made at comparatively small cost. Mr. Bessemer had informed him that if he had a large order he could produce steel shot at very little more than the price of wrought iron.

Mr. Nasmyth inquired whether chilled and cast-iron shot had been tried. The process of chilling cast iron was a very simple and inexpensive one; and if chilling flat-ended shot had not been tried it was very desirable that it should be. Mr. Fairbairn said they had no practical experience in the matter; but he believed that the shot being chilled only to a certain extent, they would find that the whole shot, having the same velocity when striking the object of resistance, would break as if it had not been hardened at all.

APPLICATION OF IRON TO THE CONSTRUCTION OF SHIPS OF WAR, AND ITS POWER TO RESIST PROJECTILES.

In a paper recently published by the eminent English engineer, Mr. W. Fairbairn, the author, in a popular manner, thus sums up the aggregate of our present knowledge respecting the following topics: —

1st. The description of iron best calculated to secure strength and durability in the construction of ships of war.

2d. The distribution and best forms of construction to attain this object.

3d. The properties of iron best calculated to resist the penetration of shot at high velocities.

Properties of Iron. — If we are desirous to attain perfection in mechanical, architectural, or shipbuilding construction, it is essential that the engineer or architect should make himself thoroughly acquainted with the properties of the materials which he employs. It is unimportant whether the construction be a house, a ship, or a bridge. We must possess correct ideas of the strength, proportion, and combination of the parts, before we can arrive at satisfactory results; and to effect these objects, the naval architect should be conversant with the following facts relating to the resisting powers of malleable and rolled iron to a tensile strain.

The resistance in tons per square inch of —

Yorkshire Iron is	24.50 tons.
Derbyshire "	20.25 "
Shropshire "	22.50 "
Staffordshire "	20.00 "

Strength of Riveted Joints. — The architect, having fortified himself with the above facts, will be better able to carry out a judicious distribution of the frames, ribs, and plates of an iron ship, so as to meet the various strains to which it may be subjected, and ultimately to arrive at a distribution where the whole in combination presents uniformity of resistance to repeated strains, and the various changes it has to encounter in actual service.

There is, however, another circumstance of deep importance to the naval architect, which should on no account be lost sight of, and that is, the comparative values of the riveted joints of plates to the plates themselves. These, according to experiment, give the following results: —

Taking the cohesive strength of the plate at	100
The strength of the double-riveted joint was	70
And the single-riveted joint	56

These proportions apply with great force to vessels requiring close riveting, such as ships and boilers that must be water-tight, and in calculation it is necessary to make allowance in that ratio.

Strength of Ships. — Of late years it has been found convenient to increase the length of steamers and sailing vessels to as much as eight or nine times their breadth of beam, and this for two reasons: first, to obtain an increase of speed by giving fine sharp lines to the bow and stern; and, second, to secure an increase of capacity for the same midship section, by which the carrying powers of the ship are greatly augmented. Now there is no serious objection to this increase of length, which may or may not have reached the maximum. But, unfortunately, it has hitherto been accomplished at a great sacrifice to the strength of the ship. Vessels floating on water, and subjected to the swell of a rolling sea, — to say nothing of their being stranded or beaten upon the rocks or sand banks of a lee shore, — are governed by the same laws of transverse strains as simple hollow beams, like the tubes of the Conway and Britannia tubular bridges. Assuming this to be true, and indeed it scarcely requires demonstration, it follows that we cannot lengthen a ship with impunity without adding to her depth, or to the sectional area of the plates in the middle along the line of the upper deck.

If we take a vessel of the ordinary construction, or what some years ago was considered the best, — 300 feet long, 41 feet 6 inches beam, and 26 feet 6 inches deep, — we shall be able to show how inadequately she is designed to resist the strains to which she would be subjected. To arrive at this result we shall approximate nearly to the truth by treating it as a simple beam; and this is actually the case, to some extent, when a vessel is supported at each end by two waves, or when, rising on the crest of a wave, it is supported at the centre with the stem and stern partially suspended. Now in these positions the ship undergoes, alternately, a strain of compression and of tension along the whole section of the deck, corresponding with equal strains of tension and compression along the section of the keel, the strains being reversed according as the vessel is supported at the ends or the centre. These are, in fact, the alternate strains to which every long vessel is exposed, particularly in seas where the distance between the crests of the waves does not exceed the length of the ship.

It is true that a vessel may continue for a number of voyages to resist the continuous strains to which she is subjected while resting on water. But supposing, in stress of weather, or from some other cause, she is driven on rocks, with her bow and stern suspended, the probability is that she would break in two, separating from the insufficiency of the deck on the one hand, and the weakness of the hull on the other. This is the great source of weakness in wrought-iron vessels of this construction, as well as of wooden ones, when placed in similar trying circumstances.

Changes in Progress. — Having directed attention to the strength of ships, and the necessity for their improved construction, we may now advert to the changes by which we are surrounded and to the revolution now pending over the destinies of the navy, and the deadly weapons now forging for its destruction. It is not for us alone, but for all other maritime nations, that these Cyclopean monsters are now issuing from the furnaces of Vulcan; and it behooves all those exposed to such merciless enemies to be upon their guard, and to have their *Warriors*, *Merrimacs*, and *Monitors*, ever ready, clothed in mail from stem to stern, to encounter such formidable foes. It has been seen, and every experiment exemplifies the same fact, that the iron ship, with its coat of armor, is of a totally different construction from that of the wooden walls which for centuries have been the pride and glory of the country. Three-deckers, like the *Victory* and the *Ville de Paris* of the last century, would not exist an hour against the sea monsters now coming into use.

The days of our wooden walls are therefore gone; and instead of the gallant bearing of a 100-gun ship, with every inch of canvas set, dashing the spray from her bows and careering merrily over the ocean, we shall find in its place a black demon, some five or six hundred feet long, stealing along with a black funnel and flag-staff, on her mission of destruction, and scarcely seen above water, excepting only to show a row of teeth on each side, as formidable as the immense iron carcass that is floating below. This may, with our present impressions, be considered a perspective of our future navies; — a view not encouraging. I have noticed these changes, which are fast approaching, from the conviction that the progress of applied science is not only revolutionizing our habits in the development of naval constructions, as in every other branch of industry; but the art of war is undergoing the same changes as the industrial arts, which have so greatly increased our resources in times of peace. It is therefore necessary to prepare for the changes now in progress, and endeavor to effect them on principles calculated not only to insure security, but to place England at the head of constructive art. It is to attain these objects that a long and laborious class of experiments have been undertaken by the government, to determine how the future navy of England shall be built; how it should be armed, and under what conditions it can best maintain the supremacy of the seas. This question does not exclusively confine itself to armor-plated vessels, but also to the construction of ships, which in every case should be strong and powerful enough to contend against either winds and waves, or to battle with the enemy. It is for these reasons that I have ventured to direct attention to the strength of vessels, and to show that some of our mercantile ships are exceedingly weak, arising probably from causes of a mistaken economy on the one hand, or a deficiency of knowledge, or neglect of first principles, on the other.

Now it is evident that our future ships of war of the first class must be long and shallow; moreover, they must contain elements of strength and powers of resistance that do not enter into the construction of vessels that are shorter and nearly double the depth. If we take a first-rate ship of the present construction, such as the *Duke of Wellington*, and compare it with one of the new or forthcoming constructions carrying the same weight of ordnance, we should require a vessel nearly twice the length, and a little more than half her depth. Let us, for example, suppose the *Duke of Wellington* to be 340 feet long and 60 feet deep, and the new construction 500 feet long and 46 feet deep; we should then have for the resistance of the *Duke of Wellington* to a transverse strain tending to break her back,

$$W = \frac{a\,d\,c}{l}.$$

Taking 60 as the constant, and the area of the bottom and upper deck as 1,060 square inches, we have

$$W = \frac{1,060 \times 60 \times 60}{340} = 11,223 \text{ tons},$$

as the weight that would break her in the middle. Let us now take the new ship, and give her the same area top and bottom, and again we have

$$W = \frac{1,060 \times 46 \times 60}{500} = 5,851 \text{ tons};$$

which is a little more than half the strength. From this it is obvious — if we are correct in our calculations — that the utmost care and attention is requisite in design and construction to insure stability and perfect security in the build of ships.

Resistance of Iron to the Penetration of Shot. — The next question for consideration is the properties of iron best calculated to resist the penetration of shot at high velocities; and in this I am fortunate in having before me the experiments of the Committee on Iron Plates, which had the following properties: — Specific gravity, 7.7621; tensile strength in tons per square inch, 24.802; compression per unit of length in tons, 14,203; statical resistance to punching in tons, one-inch plate, 40.1804.

The specimens subjected to compression gradually squeezed down to one-half their original height, increasing at the same time in diameter till they attained ninety tons on the square inch. In these experiments, four descriptions of iron were selected, marked A, B, C, D: the two first and last were taken from rolled and hammered iron plates, excepting C, which was homogeneous, and gave higher results to tension and dead pressure than the others.

In density and tenacity they stood as follows: —

Mark on Plates.	Density.	Tenacity in Tons.
A Plates, ...	7.8083	34.644
B Plates, ...	7.7035	23.354
C Plates, homogeneous, . .	7.9042	27.032
D Plates, ...	7.6322	24.171

Here it will be observed that the strengths are in the ratio of the densities, excepting only the B plates, which deviate from that law. On the resistance to compression, it will be seen that in none of the experiments was the specimen actually crushed; but they evidently gave way at a pressure of thirteen to fourteen tons per square inch, and were considerably cracked and reduced in height by increased pressure.

From the experiments on punching we derive the resistance of

A, B, C, D plates to a flat-ended instrument forced through the plate by dead pressure, as follows: —

Mark on Plates.	Shearing strain in tons per square inch.	Ratio, taking A as unity.
A Plates, ...	19.511	1.000
B Plates, ...	17.719	0.907
C Plates, ...	27.704	1.168
D Plates, ...	17.035	0.873

Here may be noticed that the difference between the steel plates of series C and the iron plates of series A is not considerable, though in all the others the steel plates exhibit a superiority in statical resistance.

Having ascertained, by direct experiment, the mechanical resistance of different kinds of iron and steel plates to forces tending to rupture, it is interesting to observe the close relation which exists between not only the chemical analysis as obtained by Dr. Percy, but how nearly they approximate to the force of impact, as exhibited in the experiments with ordnance at Shoeburyness.

Dr. Percy, in his analysis, observes, that of all the plates tested at Shoeburyness, none have been found to resist better than those lettered A, B, C, D, with the exception of C. The iron of plate E contained less phosphorus than either of the three, A, B, D, and it is clearly established that phosphorus is an impurity which tends in a remarkable degree to render the metal "cold short," *i. e.* brittle when cold.

The following table shows the chemical composition of these irons:

Mark.	Carbon.	Sulphur.	Phosphorus.	Silicon.	Manganese.
A	0.01636	0.104	0.106	0.122	0.28
B	0.03272	0.121	0.173	0.160	0.029
C	0.023	0.190	0.020	0.014	0.110
D	0.0436	0.118	0.228	0.174	0.250
E	0.170	0.0577	0.0894	0.110	0.330

Comparing the chemical analysis with the mechanical properties of the irons experimented upon, we find that the presence of 0.023 per cent. of carbon causes brittleness in the iron; and this was found to be the case in the homogeneous iron plates marked C; and although it was found equal to A plates in its resistance to tension and compression, it was very inferior to the others in resisting concussion or the force of impact. It therefore follows that toughness combined with tenacity is the description of iron plate best adapted to resist shot at high velocities. It is also found that wrought iron, which exhibits a fibrous fracture when broken by bending, presents a widely-different aspect when suddenly snapped asunder by vibration, or by a sharp blow from a shot. In the former case the fibre is elongated by bending, and becomes developed in the shape of threads as fine as silk, whilst in the latter the fibres are broken short, and exhibit a decidedly crystalline fracture. But, in fact, every description of iron is crystalline in the first instance; and these crystals, by every succeeding process of hammering, rolling, etc., become elongated, and resolve themselves into fibres. There is, therefore, a wide difference in the appearance of the fracture of iron when broken by tearing and bending, and when broken by impact, where time is not an element in the force producing rupture.

From a series of experiments made at Manchester it was found that with plates of different thicknesses the resistance varies directly as the thickness; that is, if the thickness be as the numbers 1, 2, 3, etc., the resistance will be as 1, 2, 3, etc.; but those obtained by impact at Shoeburyness show that up to a certain thickness of plate the resistance of projectiles increases nearly as the square of the thickness. That is, if the thickness be as the numbers 1, 2, 3, 4, etc., the resistance will be as the numbers 1, 4, 9, 16, etc., respectively. The measure, therefore, of the absolute destructive power of shot is its *vis viva*, not its momentum, as has been sometimes supposed, but the work accumulated in it varies directly as the weight of the shot multiplied into the square of the velocity.

There is, therefore, a great difference between statical pressure and dynamical effect; and in order to ascertain the difference between flat-ended and round-ended shot, a series of experiments were undertaken with an instrument or punch exactly similar in size and diameter and precisely corresponding with the steel shot employed in the experiments at Shoeburyness. The results on the A, B, C, and D plates are shown in the following table:—

Character of Plates.		Resistance in lbs	
		Punch flat-ended.	Punch round-ended.
Half-inch thick . .	A Plates,	57,956	61,886
	B Plates,	57,060	48,788
	C Plates,	71,035	85,524
	D Plates,	49,080	43,337
Three-quarter-inch thick	B Plates,	84,587	98,420
	D Plates,	82,381	98,571
Mean, ...		67,017	72,754

These figures show that the statical resistance to punching is about the same, whether the punch be flat-ended or round-ended, the mean being in the ratio of 1000 : 1,085, or 8½ per cent. greater in the round-ended punch. It is, however, widely different when we consider the depth of indentation of the flat-ended punch, and compare it with that produced by the round-ended one, which is $3\frac{1}{2}$ times greater. Hence, we derive this remarkable deduction, that whilst the statical resistance of plates to punching is nearly the same, whatever may be the form of the punch, yet the dynamic resistance or work done in punching is twice as great with a round-ended punch as with a flat-ended one. This, of course, only approximately expresses the true law; but it exhibits a remarkable coincidence with the results obtained by ordnance at Shoeburyness, and explains the difference which has been observed in these experiments, more particularly in those instances where round shot was discharged from smooth-bored guns at high velocities. To show more clearly the dynamic effect or work done by the weight of shot which struck some of the targets at different velocities, the following results have been obtained: —

Target.	Weight of shot striking target; lbs.	Work done on Target.	
		Total Foot lbs.	Per square foot. Foot lbs.
Thorneycroft 8-inch Shield, .	1253	——	29,078,000
Thorneycroft 10-inch Embrasure,	1511	——	37,140,000
Roberts's Target, ...	946	822,000	19,726,000
Fairbairn's Target, ...	1024	324,000	23,311,000
Warrior Target, ...	3229	312,000	62,570,000
The Committee's Target, . .	6410	——	124,098,780

From the above it will be observed that the two last targets have sustained in work done what would, if concentrated, be sufficient to sink the largest vessel in the British navy.

We are all acquainted with the appearances and physical character of artillery, but few are conversant with the nature of the operations and the effects produced by shot on the sides of a ship, or on resisting forts and targets.

The shot of a gun is simply the means of transferring mechanical power from one place to another. The gunpowder in the gun develops, by its combustion, a certain quantity of mechanical force, or work, as it is now called, and the object of the shot is to convey this work to a distance, and apply it to an object supposed to be otherwise inaccessible. The effect of this, according to Mr. Pole's formula, is —

$W =$ weight of the shot in pounds.
$V =$ its velocity in feet per second.

Then, by the principle of *vis viva*, the quantity of work stored up by the moving mass, measured in pounds, one foot high, is

$$= \frac{WV^2}{2g},$$

g being the force of gravity $= 32\frac{1}{6}$.

Thus, if we have a shot, like that recently used against the Warrior target, 156 pounds, moving at the rate of 1,700 feet per second, the work done will be —

$$= \frac{156 + (1700)^2}{64\frac{1}{3}} = 7{,}008{,}238 \text{ one foot high.}$$

Showing at once the immense power that this small body is able to deliver on every resisting medium tending to arrest its course and bring its particles to a state of rest. Or, in other words, it is equivalent to raising upwards of 3,000 tons a foot high in the air.

Application of Iron for Defensive Purposes. — But let us next consider in what form, and under what circumstances, iron can best be applied for the security of vessels and forts. To the latter the answer is, make the battery shields thick enough; but a very different solution is required for the navy, where the weight and thickness of the plates is limited to the carrying powers of the ship. If our new construction of ships are strong enough to carry armaments of 300-pounder guns, which is assumed to be the case, our plating of six or seven inches thick would be penetrated, and probably become more destructive to those on board than if left to make a free passage through the ship. In this case we should be exactly in the same position as we were in former days with the wooden walls; but with this difference, that if built of iron the ship would not take fire, and might be made shell-proof. It is, however, very different with forts, where weight is not a consideration, and those, I am persuaded, may be made sufficiently strong to resist the heaviest ordnance that can be brought to bear against them. In this statement I do not mean to say that ships of war should not be protected, but we have yet to learn in what form this protection can be effected to resist the powerful pieces of ordnance, and others of still greater force which are looming in the distance, and are sure to follow.

A great outcry has been raised about the inutility of forts; and the government, in compliance with the general wish, has suspended those at Spithead; I think improperly so, as the recent experiments at Shoeburyness clearly demonstrate that no vessel, however well protected by armor-plates, could resist the effects of such powerful artillery; and instead of the contest between the *Merrimac* and *Monitor*, and that of the 300-pounder gun, being against, the results are to appearance in favor of forts. Should this be correct, we are now to consider how we are to meet and how resist the smashing force of such powerful ordnance as was levelled against the Warrior target.

During the whole of the experiments at Shoeburyness I have most intently watched the effects of shot on iron plates. Every description of form and quality of iron has been tried, and the results are still far from satisfactory; and this is the more apparent since the introduction of the large three-hundred-pounder, just at a time when our previous experiments were fairly on the balance with the forty, sixty-eight, one-hundred, and one-and-twenty-six-pounders. They now appear worthless, and nothing is left but to begin our labors again *de novo*.

It has been a question of great importance, after having determined the law of resistance and the requisite quality of the iron to be used as armor-plates, how these plates should be supported and attached to the sides of the ship. Great difference of opinion continues to exist on this subject; some are for entirely dispensing with wood; probably the greater number contend for a wood backing. I confess myself in the minority on this question; and, judging from the experiments, I am inclined to believe from past experience that wood combined with iron is inferior to iron and iron in its power of resistance to shot; and I am fully persuaded that ultimately the iron armor-plates must be firmly attached to the side, technically called the skin, of the ship. It must, moreover, form part of the ship itself, and be so arranged and jointed as to give security and stability to the structure. It must, however, be admitted that plates on wood backing have certain advantages in softening the blow, but this is only at the expense of the plate, which is much more deflected and driven into the wood, which, from its compressibility, presents a feeble support to the force of impact. Again, with wood intervening between the ship and the iron plates it is impossible to unite them with long bolts so as to impart additional strength to her; on the contrary, they hang as a dead weight on her sides, with a constant tendency to tear her in pieces. Now, with iron on iron, we arrive at very different and superior results. In the latter, the armor-plates, if properly applied, will constitute the strength and safety of the structure; and, notwithstanding the increased vibration arising from the force of impact of heavy shot, we are more secure in the invulnerability of the plates, and the superior resistance which they present to the attack of the enemy's guns. In these remarks, I must not, however, attempt to defend iron constructions where they are not defensible, and I am bound to state that in constructions exclusively of iron there is a source of danger which it is only fair to notice, and that is, that the result of two or more heavy shot, or a well-concentrated fire, might not only penetrate the plates, but break the ribs of the ship. This occurred in experimenting on a target of iron of my own construction, where a salvo of six guns concentrated four on one spot, not more than fourteen inches in diameter, went through the plates, and carried away a part of the frame behind. The same effect might have taken place with any other target; and certainly nine inches of wood are of little value when assailed by a powerful battery of heavy ordnance and a well-concentrated fire.

MANUFACTURE OF ARMOR-PLATES.

From a paper recently contributed to the Institution of Mechanical Engineers, Birmingham, Eng., by Mr. John Brown, of Sheffield, and published in the London *Mechanics' Magazine*, we make the following extracts respecting the process by which iron plates for the armor of ships are fabricated in Great Britain: —

Two methods of producing large masses of wrought iron have been in use; the first by the process of building up under the steam-hammer, and the second by building up under the rolls. Under the steam-hammer, the plate is produced by welding together lumps or masses of scrap iron, each mass of scrap being added and welded to the end of the plate, until it reaches the required length. Plates made in this way have been seriously objected to on account of their brittleness; and it is reasonable to suppose that this mode of manufacture is somewhat likely to induce brittleness. There can hardly be any continuity of fibre in a plate forged from masses of scrap iron, perhaps of different qualities, each of different heats; the nature of the weld and its form, and the repeated cooling and re-heating of the plate, are also adverse to its possessing great toughness. The rolled plates have been found more uniform in quality and of greater toughness than the hammered; and though the difficulties in their manufacture are grave, there is no departure from the ordinary practice followed in making large plates for other purposes. The difficulties which do exist are chiefly due to the immense weight and size, and the intolerable heat of the mass, which must be dealt with while at a welding temperature.

The general size of the armor-plates required for the plated frigates now building in England is from fifteen to eighteen feet long, from two feet six inches to three feet ten inches wide, and four and one-half inches thick. The weight therefore of the finished plate ranges from sixty to one hundred and ten hundred-weight; and in the unfinished state it comes from the rolls at eighty to one hundred and forty hundred-weight. From three to four inches is cut off the sides, and ten or twelve from each end; and in this item of waste the hammering process has an advantage over the rolling.

The mode of manufacture of a five-ton plate is as follows: Bars of iron are rolled twelve inches broad by one inch thick, and are sheared to thirty inches long. Five of these bars are piled and rolled down to a rough slab. Five other bars are rolled down to another rough slab, and these two slabs are then welded and rolled down to a plate of one and one-quarter inches thick, which is sheared to four feet square. Four plates like this are then piled and rolled down to one plate of eight feet by four feet and two and one-half inches thick; and, lastly, four of these are piled and rolled to form the final entire plate. There are thus welded up together one hundred and sixty thicknesses of plate, each of which was originally one inch thick, to form when finished four and one-half inches, making a reduction of thirty-five times in thickness; and in this operation from thirty-five hundred to forty hundred square feet of surface have to be perfectly welded by the process of rolling. It is not surprising that even with the greatest care blisters and imperfect welds should exist and render the plate defective; this is the chief difficulty to be overcome, and a very serious one it is; and as the magnitude and weight of the plate increase, so does also the liability to failure. The final operation of welding the four plates of eight feet by four feet by two and one-half inches is a very critical matter. To bring a pile of four plates of these dimensions up to a perfect welding heat all through the mass, without burning the edges and ends of the plates most exposed to the fire; to drag this pile out of the furnace, convey it to the rolls, and force it between them, in so short a time as to avoid its losing the welding heat, is a matter of greater difficulty than those unacquainted with the work would imagine. The intensity of the heat thrown off is almost unendurable, and the loss of a few moments in the conveyance of the pile from the furnace to the rolls is fatal to the success of the operation.

A pile of four plates, heated in a special furnace, is drawn out by a liberating chain attached to the roll on to an iron carriage, which conveys the pile to the rolls. The carriage travels upon a line of rails let into the ground; and close in front of the roll frame is a small incline upon the railway, which lifts up the front of the carriage at the moment of its arrival at the rolls, and enables it to deliver the pile upon the fore plate. As the plate passes through the rolls it is received on the other side upon a roller frame, which is set at a considerable inclination toward the rolls, so that the tendency of the plate is to return. The rolls are then reversed; and the plate which was pressing against them passes back through, and is received upon the carriage; and again the operation is repeated, until the ten inches thickness is reduced to four and one-half inches. The plate is then lifted off the carriage by a crane, and deposited upon a massive cast-iron straightening bed. Here an iron cylinder weighing nine tons is rolled over it to and fro, being pinched along by hand levers, until the curvature which the plate has acquired in the rolling is entirely removed. As soon as the plate is sufficiently cool, it is lifted off the straightening bed by another crane, and laid upon a planing machine, where the final operation of planing its sides and ends is completed.

RECENT APPLICATIONS OF SCIENCE CONTRIBUTING TO THE EFFICIENCY AND WELFARE OF MILITARY FORCES.

The following are abstracts of points noticed in a lecture on the above subject, recently delivered by Mr. Abel, Director of the Chemical Establishment of the British War Department: —

A subject of importance in connection with the repeated firing of a rifled gun relates to the solid substances, or residue, obtained on the explosion of powder, particularly in a confined space, such as the barrel of a gun. In the old smooth-bore cannon or small-arms this residue was carried away, to a very great extent, on the discharge of the piece, by the sudden rush of gas, so that a cannon could easily be kept clean by the employment of a mop or sponge after the discharge. But in the case of the rifled gun with expanding projectile, which may be regarded as a close chamber for a short interval after the discharge (as the projectile, when acted upon by the exploded powder, exactly fits the bore of the gun), this escape of the gas is, comparatively speaking, greatly retarded, so that the residue is no longer held in suspension and swept out of the gun to any important extent. It is, moreover, powerfully compressed by the force of the discharge; consequently we find large masses of residue accumulating in the barrel. Its quantity is, moreover, greatly increased by the charred remains of the cartridge-bag, which, in the smooth-bore gun, is almost entirely expelled on the discharge. It has therefore been a matter of great importance to promote the removal of this residue, so that each discharge should at any rate carry away the dirt or residue left by the preceding one. In cannon this is very readily effected by the employment of a wad of hemp or some similar material thoroughly saturated with fatty matter, or by the use of a cake consisting of the lubricating material only. Sir W. Armstrong places a lubricating wad between the powder and the projectile; Mr. Whitworth encloses the charge of powder in a metallic case, which he closes with a cake of lubricating material. On the discharge of the gun the fatty matter is in both instances distributed over the whole of its internal surface, and effectually promotes the removal of the residue. Mr. Whitworth's metallic cartridge is removed from the gun after the discharge; by its use he avoids adding to the residue of the powder the charred remains of a combustible cartridge-bag, and he also removes, in the case, that portion of the powder residue which would otherwise be deposited in the breech of the gun.

In the case of rifled small-arms the use of wads is considered objectionable, except in special instances; the lubricant has, therefore, to be applied to the exterior of that portion of the cartridge-paper which surrounds the bullet. The selection of a suitable lubricating material for this purpose has been attended with considerable difficulty. Tallow was first employed, in admixture with sufficient beeswax to harden it somewhat, and to enable it to resist the effects of warm climates. It was found, however, after some time, that the tallow, penetrating the paper, exerted a corrosive action upon the metal. It is well known that when such an action is once established upon the surface of lead it will, under favorable conditions, readily extend into the mass of the metal, the original diameter of which becomes much increased as the oxide of lead formed combines with carbonic or other acids and water. These bullets [alluding to specimens on the table] were contained in a shrapnell shell, and they represent the condition in which many others were found after remaining for some time in store. They were all of the same diameter originally. In some of these bullets there is only a small central nucleus of compact lead remaining. This corrosion was undoubtedly established in the first instance by a small quantity of acid matter derived from the crude corks with which the shells were closed, and which was conveyed into the shell by moisture penetrating through the cork. The destruction of these bullets has been the result of a very gradual corrosion, continuing for several years. But here are bullets, very considerably corroded, covered in several places with a hard crust of compounds of oxide of lead, whereby their diameter has become so greatly increased that they cannot without much difficulty be introduced into the rifle barrel. These bullets have only been exposed for a few months to the air in contact with a small quantity of fatty matter, such as tallow, which, becoming acid by atmospheric exposure, has established and carried on this corrosive action upon the lead. The difference between the original diameter of an Enfield rifle bullet and that of the barrel only amounts to 0.23 of an inch, and this is diminished to 0.1 of an inch by the paper and lubricant which surround the bullet. You will therefore readily understand how a slight increase in the diameter of the ball, due to the formation on its surface of a hard crust of the products of corrosion, might render its introduction into the barrel difficult or impossible, particularly in active service. It therefore became necessary to replace the tallow mixture by some other lubricating material which would not affect the bullets injuriously. Just about the time that the disturbances in India commenced, the subject was receiving investigation, and, after very searching trials, beeswax was found to be the most suitable material. Though so very dissimilar to the substances generally used as lubricants, its cleansing properties in the barrel of an arm are remarkable; it produces a beautiful glazing or surface upon the metal, which prevents the adhesion of any of the residue. When pure it exhibits no tendency to promote the corrosion of lead, nor does it undergo by long preservation any change likely to prove injurious to the metal. After the introduction of beeswax it was found necessary to discontinue the use of the ordinary vegetable oils, applied to the lubrication of bullet-making machines, as it was discovered that even the minute quantity of oil remaining upon the bullet after it left the machine and had been cleaned was sufficient to establish a corrosive action upon the lead. Recourse was therefore had to the neutral and permanent lubricating oil prepared from petroleum.

All are doubtless aware that voltaic electricity has been successfully applied, for some time past, to the discharge of mines. The limits of my time will not permit to enter into details with respect to the methods hitherto in use for calling into play the heating powers of the voltaic current to the ignition of powder, which, I may just remind you, are based upon the resistance offered to the passage of a voltaic current through a metallic circle by fine metal wires of inferior conducting powers, such as iron or platinum. By the introduction of short lengths of such wires into those portions of the circuit which pass through the charges of powder, the passage of the current will cause them to become heated to such an extent as to effect the ignition of the powder. Although by such, or similar arrangements, one or two mines may be discharged with certainty by the direct application of the current obtained from a battery of moderate power, more extensive, and particularly sub-marine operations, can only be effected by the employment of very powerful batteries, and are even then attended with considerable uncertainty. These circumstances, combined with the very great inconvenience and risk of accident attending the transport of the battery and the acids and other materials required to set it in operation, and the numerous points to be attended to in order to ensure the full development and application of the battery power, have led to the prosecution of numerous experiments, in different continental States and in this country, for the purpose of rendering this particular application of electricity more certain and simple. Some successful results have attended the use of the electricity of high intensity obtained by means of the powerful electro-magnet coil-machines constructed by Ruhmkorff and others. By their employment, with appropriate fuse arrangements for effecting the ignition of the charge by means of the spark, the battery-power necessary for firing a number of mines is very considerably reduced. The most perfect of these coil-machines, even when arranged in a form suitable for transport, are, however, very liable to injury, particularly in the hands of those not thoroughly acquainted with the principles and delicacy of their construction. Their employment, moreover, still necessitates the use of the voltaic battery. Although, therefore, these machines doubtless admit of application with great advantage in special cases, they are not likely to be generally substituted for the old arrangements.

In Austria very important results are said to have been obtained by the employment of frictional in the place of voltaic electricity. A very portable arrangement of a plate-electric machine, with Leyden jars and the other necessary implements, and with a small stove attached to protect the apparatus from the prejudicial interference of damp, has been employed with success in some extensive operations in that country, as many as one hundred charges having been simultaneously fired by its means.

Some results obtained in connection with Professor Wheatstone, in prosecuting an experimental inquiry into the merits of the different forms of electricity in their special application to the explosion of mines, are worthy of notice: — Our attention being particularly directed to the application of the electricity obtained by induction from permanent magnets, it was found that, although gunpowder could be ignited by the magneto-electric spark, the explosion of a single charge, by the use even of one of the most powerful magneto-electric machines, could not be relied upon with any degree of certainty. By employing, as a priming material, a gunpowder slightly modified in its composition so as to increase its conducting power, the ignition of one charge, but of one only, was effected with certainty. After trying with no better success a large number of explosive compositions of a more sensitive character than gunpowder, I at length lighted upon a material which combined the properties evidently essential to the successful employment of the magnet, namely, considerable sensitiveness as an explosive and moderate power of conducting the current. By its employment as the priming material, in connection with an appropriate fuse arrangement for the purpose of permanently fixing it in a position most favorable to the proper action of the current, it was no longer necessary to employ a powerful magnet to effect with certainty the explosion of single charges. Here is a small electro-magnetic machine of comparatively low power, of the kind and size employed by Mr. Wheatstone in his smallest portable magneto-electric telegraph instruments. I have connected with it, by means of these two long wires, two small charges of powder, each containing the primed fuse just referred to. You will perceive that as soon as the action of the instrument is established by setting in very rapid motion this little arrangement of multiplying wheels in connection with the movable armature, the charges are exploded. Advantage is taken of the very rapid succession of currents obtained from such an instrument as this, or, better still, of an arrangement of several such electro-magnets, to effect the ignition of a considerable succession of charges with such great rapidity, that the result is practically the same as though the explosion of the whole number occurred instantaneously. A portable combination of several of these little instruments, such as has readily been devised by Mr. Wheatstone, and is contained in this small box, is all that is, therefore, required, in addition to fuses and connecting wires, for exploding, at the shortest notice, a considerable number of mines. The advantages offered by the use of such an apparatus are very important. With the most ordinary care it is not liable to injury or disarrangement; it is exceedingly transportable and ready for use at any moment, and the soldier requires but very little instruction in its employment. He has only to place the instrument in connection with the mines and the earth by means of these screws, to turn this handle as rapidly as possible, and to depress this key when the signal to fire is given. It will, I believe, be evident to all present that this system is very greatly to be preferred to the plan of exploding mines by voltaic agency.

Before quitting this subject I must just allude to the successful application which has been made of vulcanized India-rubber to the preparation of receptacles for the powder-charges employed in submarine operations. Such bags are perfectly water-tight under very considerable pressure; they are far more easily transportable and generally manageable than the wooden or metal vessels which have hitherto been employed for the reception of powder to be exploded under water.

The following plan for *protecting wooden camp-huts from fire* has been found efficient in the British service: — It consists in coating the wood with a species of artificial stone (a double silicate of lime and soda), readily produced by applying alternately a solution of soluble glass and lime-wash to the surface of the wood. This coating has been found to offer very great resistance to fire, and to be very durable when exposed to the effects of rain and cold. Attempts have been quite recently made to afford a similarly permanent protection to tents, by the employment of silicate in some form, which have led to the discovery of a simple process whereby canvas may be thoroughly impregnated with an insoluble silicate, which protects it to a remarkable extent from fire.

The *regular supply of drinkable and wholesome water to troops* at foreign coast-stations, and in positions temporarily occupied in time of war, has on many occasions been attended with formidable difficulties, which in some cases have been met by the employment, in such localities, of the apparatus introduced by the late Sir Thomas Grant, for the production of fresh water, on board ship, from sea-water, and which has, for some time past, been extensively used in the navy. The apparatus simply consists of an efficient condenser, whereby distilled water is produced from the steam generated in the ship's or other boilers. The product, which exactly resembles ordinary distilled water, though drinkable, is by no means pleasant, when first obtained; it is entirely wanting in the briskness more or less common to all fresh water, and which is due to the gaseous matter contained in solution. If this water be, however, kept in partially filled tanks for some time, and particularly if by the motion of a vessel, for example, it be maintained in continual or frequent agitation, it becomes partly aërated, and is thus rendered somewhat more palatable. It always possesses, however, the peculiar unpleasant flavor of distilled water which has been produced from steam generated in metal vessels, and which is due to the presence, in solution, of minute quantities of empyreumatic matter resulting from the decomposition of organic substances contained in the water. This flavor may be at once removed by passing the aërated water through a vessel containing charcoal, which absorbs the minute quantities of organic matter, and promotes their rapid oxidation by the oxygen dissolved in the water.

By combining the application of this fact with a simple, ingenious, and very efficient method of aërating the distilled water, Dr. Normandy has succeeded in effecting one of the most important and recent improvements in the purification of water, and one which has already received several applications in connection with the military service, though its benefits will unquestionably be far more extensively experienced by all branches of the marine service. The following is substantially the action of Dr. Normandy's apparatus: — The heat of the steam which passes over from the boiler into the apparatus is made to perform, in succession, two important operations. In the first instance, it is applied to the production of a fresh quantity of steam (equal in volume to that obtained from the boiler); this is very simply effected by employing so small a volume of water for condensing the first steam (which always enters the apparatus under a slight pressure) that the former is speedily raised to a temperature at which it is rapidly converted into steam, and at which it is maintained by suitable arrangements. This second portion of steam is made to pass into another condenser, differing in its arrangement from the first in this, that the condensing water employed in it is very gradually but continuously replaced, so that, though its temperature is not raised to the same extent as that in the first condenser, it becomes sufficiently hot, before it passes out of the apparatus, to part with nearly the whole of the gaseous matter which it contains in solution. The gas thus expelled from the water is made to mix with the steam produced in the apparatus, as described just now, so that the latter, on its condensation, furnishes distilled water, thoroughly saturated with the gaseous matter derived from the original water. This aërated product, in passing into a refrigerator, mixes with the first product, which is simply ordinary distilled water, and the whole then flows through a cylindrical vessel filled with wood-charcoal, from which it issues as bright and sparkling water, completely free from any trace of the usual flavor of distilled water, and as palatable as the best spring water. An apparatus of this kind was employed to supply the German Legion with water at Heligoland during the late war; two of large size have been dispatched to China for the hospital ships, and I believe that many cases will occur in which it will be applied with great benefit to the supply of wholesome water to troops.

Grant's Cooking Apparatus for the field, which is a great improvement as regards economy and comfort, and which has been introduced into the British service, consists of a number of long cylindrical kettles (which may, if necessary, be made to serve the purpose of pontoons), and which are used in the following manner: Four trenches are dug in the form of a cross, each of sufficient length to receive two kettles placed end to end, and of such other dimensions that the kettles shall be supported by the sides of the trenches, of which the lower portions are thus converted into flues, all communicating with a central sheet-iron chimney. The kettles are, therefore, heated by kindling a fire at the extremity of each trench, and with eight of these kettles, arranged in this manner, sufficient food for eight hundred men can be cooked in about three hours with a very small expenditure of fuel.

SOME OF THE CAUSES, EFFECTS, AND MILITARY APPLICATIONS OF EXPLOSIONS.

The following is a report of a lecture on the above subject recently delivered before the Royal Institution, London, by Mr. Abel, director of the chemical establishment of the British War Department.

The phenomena which we are in the habit of classing under the term explosions are all due, I need scarcely say, to a sudden and considerable expansion of matter. The successful effort, for example, of confined particles of air to escape from the bonds within which they have been compressed, and to re-assume the position which they originally occupied relatively to one another, is always accompanied by the production of sound, the violence of which is regulated by the extent and suddenness of the expansion and the amount of resistance to be overcome, and, consequently, by the violence with which the particles of air dash against and impart vibration to the surrounding atmosphere, or other particles of matter with which they come into collision; as is the case when I compress air within this bladder, until a point is reached at which the cohesive force, holding the particles of the bladder together, is overcome by the pressure exerted from within, and we have a sound produced. [This was illustrated by air's being forced by a syringe into a small India-rubber balloon until the pellicle burst with a slight report.] What we call explosions may also be produced by a sudden or very rapid conversion of solid or liquid into a gas or vapor, by the sudden change of state (as we commonly call it) of matter, brought about by the action of heat, which is therefore one great — in fact the most important — source of explosions.

As it is, however, impossible to treat the whole subject of explosions in one lecture, I therefore confine myself to the consideration of those explosions which are brought about directly or indirectly by chemical agency.

When chemical action produces, or is followed by, an explosion, we know that the main cause of that explosive effect or result, of which I have just endeavored to point out the general nature, is the development of heat consequent upon the disappearance of chemical activity; and we also know that the amount of heat — if I may use this term in speaking of such an agency of heat — corresponds to the energy of the chemical action; just in proportion, therefore, as we have chemical energy exhibited, we have heat developed. There is another cause to which we may refer the production of explosions, and that is the alteration in the state of matter resulting simply from chemical change. Solids may, as you all know, be, under these circumstances, converted into vapors or gases; such changes may be effected very suddenly, and quite independently of any heat developed; and the sudden expansion thus brought about would naturally produce the effect of an explosion. We may readily conceive that, if a small quantity of powder, such as the charge used in a small-arm or rifle (weighing about seventy-five grains), were suddenly converted, independently of the action of heat, into a considerable volume of gas, an explosive effect would be produced. But, accompanying this change of state, we have, in the actual case of the explosion, very intense heat developed, resulting from the chemical transformation; and that heat, by its expansive effect, contributes far more to the production of the violent explosion than the mere alteration of state resulting from the chemical change. This may readily be rendered evident by comparing the volume of gas which, by theory, would be produced by ignition of the powder, taking into consideration the expansive action of the resulting heat, with the comparatively small volume which the gas would occupy at common temperatures. [The difference in volume of the charge of gunpowder and other gases produced under the above circumstances was illustrated by means of cubes.]

Now, there are several classes of chemical action by which explosions may be brought about. First, we are acquainted with a few instances in which explosions result from chemical combination, as in the case of some elementary bodies which possess a tendency to enter into combination with great energy, and consequently with explosive violence. There are numerous instances of combination of a very energetic character, especially between compound bodies, but very few of them, indeed, produce explosive results, simply because the combination proceeds in comparatively a gradual manner. As I have said before, it just depends upon the rapidity of action we can establish between bodies — upon the intensity of chemical affinity exhibited by bodies when they are brought together — whether we produce a sufficiently sudden expansion of matter to bring about an explosion. In a case of feeble chemical action, such as that of an acid upon a weak base, heat is developed but slowly and to comparatively a slight extent, because of the very gradual nature of the combination. Thus, if we dissolve this oxide of zinc, which is a weak base, in acid, the heat developed will only gradually melt the very fusible material (paraffin for instance) with which this vessel is coated. This is an example of feeble chemical action. If we proceed a step further, taking, for example, such a substance as this oxide of phosphorus (anhydrous phosphoric acid), which possesses great chemical affinity for water, and we allow it to combine with a small quantity of that liquid, we observe that it will do so much more energetically than the oxide of zinc did with the acid, producing almost an explosive result. We have a proportion of the water suddenly converted into vapor by the heat developed, which is sufficiently intense to ignite a highly combustible material, as we find if we allow gun-cotton to come in contact with the oxide of phosphorus which we are combining with water. If two very active elementary bodies, such as bromine on the one hand and potassium (or iron) on the other, are brought together, we find that a still more violently rapid combination takes place. No substance existing naturally in the form of a vapor or gas is produced by their combination; it is simply here the intense heat, suddenly generated by bringing these two substances together, which suffices to produce a powerfully explosive result, by instantaneously generating a quantity of vapor. And, lastly, if we take a mixture of two gases, such as hydrogen and oxygen, or hydrogen and chlorine, and confine them as we have in this glass vessel, we know that the mere momentary contact of some portion of the mixture with a body raised to a high temperature, or the passage of an electric spark through it, or in the latter case the rays of the sun, produce instantaneous combination throughout the whole volume of gas. A violent explosion takes place, and the vessel is shattered into innumerable minute fragments, in consequence of the enormous force suddenly exerted by the intensely heated product of combination of the gases.

These are one or two instances in which combination produces explosion. We can produce a much greater variety of examples in which explosion is the result of the instantaneous or very rapid decomposition of a chemical compound. We are acquainted with several classes of compounds remarkably unstable in their character, — these are to be found particularly among the bodies which we term organic; there are, however, a few inorganic compounds which are also remarkable for their instability; such are the combinations of hydrogen and nitrogen with chlorine, bromine, and iodine. This, for instance, is the iodide of nitrogen, which is formed whenever iodine and ammonia are brought together. If it is sufficiently dry, a very slight touch will cause the explosion. The combinations of mercury and of silver with carbon, nitrogen, and oxygen, which we know as the fulminates, are remarkably explosive in their character. When these fulminates are perfectly dry, a very slight blow or a very small amount of friction is sufficient to bring about their decomposition. Thus, here is a small quantity of fulminate of mercury; you will observe that a very slight application of heat to this is sufficient to cause it to undergo decomposition. It inflames with a dull sort of sound, which would, of course, be rendered more violent if the particles were confined. Here is some fulminate of silver, which is much more explosive in its character. We will take a much smaller portion of this than of the other fulminate, and place it upon the copper, and submit it to the action of the heat. [This was done.] You see it explodes much more readily and violently, and we perforate the copper instantly; while in the case of the mercury compound the copper was hardly indented. As I have said, the explosive characters are exhibited by various organic compounds — bodies not of natural occurrence, but produced from non-explosive organic substances by the action of an acid remarkable for the amount of oxygen which it contains, and for the tendency which it has to impart that oxygen to other substances — nitric acid. This nitric acid, as many of you know, may be made to produce changes in organic substances, resulting in the oxidation of a proportion of hydrogen-atoms in the organic structure, and their removal in the form of water; a corresponding proportion of the partially de-oxidized acid (nitrous acid) passing into the space created by the abstraction of the hydrogen from the group; and thus we can produce, for example, from cotton, from cellulose, or lignine, highly explosive substances.

There is also an explosive substance produced by a similar action of nitric acid upon the sweet principle of manna, beet-root, parsnips, or onions, known as mannite; it is nitromannite. Again, we are enabled by the mere contact of nitric acid, in its most concentrated form, at a low temperature, with glycerine, to produce a substance of a highly explosive character known as nitroglycerine or *glonoïne*. It is only necessary to moisten a small portion of filtering-paper with a little of this substance, and then to expose this to a moderately violent blow, in order to show its explosive nature.

One of the most recently-discovered and curious of these explosive organic bodies is the nitrate of diazobenzol, obtained by the action of nitrous acid at a low temperature upon aniline. This substance explodes at least as violently as iodide of nitrogen and fulminate of silver, if exposed to a heat approaching that of boiling water; it is, however, far less sensitive to friction than those two bodies. Similarly explosive substances have been quite recently obtained by Dr. Hoffmann from derivatives of the interesting and important base, rosaniline, the salts of which furnish some of the most beautiful of the colors now obtained from aniline.

Explosions are most readily produced by establishing chemical action between certain substances greatly opposed to each other in their properties, and brought together in an intimate state of mixture. The substances applicable to the production of such mixtures are, on the one hand, bodies remarkable for their great affinity for oxygen, and, on the other, compounds containing that element in abundance, and partly or entirely in a loose state of combination. To the first class belong the elements carbon, sulphur, and phosphorus, and compounds of the last two with readily oxidizable metals. The second class includes a few of the higher metallic oxides, such as the higher oxides of manganese and lead, and combinations of metals with nitric, chloric, and perchloric acids. Mixtures produced with these two classes of bodies readily ignite, or afford explosions, either upon the direct application of heat, or by submitting them to friction, percussion, or concussion; and, in a few instances, by establishing chemical action in a small portion of the mixture, with the aid of some other compound. These explosive mixtures vary greatly in the ease with which chemical action is established in them, and in the rapidity and violence of their transformation; their properties are naturally regulated by the chemical and physical characters of their constituents, and by the degree of intimacy of their mixture.

The variation in their explosive properties, and the great extent to which the characters of any particular mixture may be modified, are very important elements in their application to practical purposes; while the comparatively instantaneous nature of the decomposition of explosive compounds, and the facility with which it is brought about, present very great, and in many cases insuperable obstacles to their employment as explosive agents.

A very slight examination into the effects of fulminate of mercury and of gunpowder, employed under the same circumstances, will illustrate the difference in the effects produced by substances which explode with different rapidity. Let me first compare the rate of combustion of those two substances. Here is a small train of fulminate of mercury, and here is a similar train of gunpowder. You observe that the flame travels much more rapidly along the train of fulminate than along the gunpowder. This difference will prepare you to believe that the effect of the two when confined in vessels must be different. Here are the fragments produced by the explosion, in a small shell, of 100 grains of fulminate of mercury; a number (amounting to one-seventh of the weight of the shell) were, however, so small that they could not be recovered after the explosion. Here are the fragments of a shell of the same size exploded by 765 grains of gunpowder. The difference between the size and number of the fragments in the two instances is very striking. In the case of the fulminate of mercury the explosive effect is exerted almost instantaneously in all directions, and the shell is therefore shattered into a very large number of fragments, the force of the explosion being almost entirely spent on the bursting of the shell; while in the case of gunpowder, the explosion being comparatively gradual in its nature, the force developed is only partly spent upon the fracture of the shell, and is still in course of development when this result is produced; hence, not only are the resulting fragments much fewer and larger, but a considerable projectile force is exerted upon them after their production, and they are consequently scattered to a much greater distance than those produced by the employment of fulminate of mercury.

When gunpowder is confined by means of a shot or shell in the barrel of a gun, the explosion of the first particles has the effect of overcoming the inertia of the projectile, and the action proceeding gradually, as compared, for instance, to that of the fulminate of mercury, the shot is projected with comparatively small strain upon the gun; but in employing the fulminate of mercury, in a corresponding experiment, it would be found that the enormous force, which reaches its maximum suddenly, would, almost simultaneously with the first movement of the shell, also discover the weakest parts of the gun; in all probability, therefore, the cannon would be burst, while we should not project our shot or shell to any great distance. In quarrying, where it is desired to detach large masses of rock or stone, without producing any great destructive effect, we employ a very slow-burning powder, the explosion of which exerts a force like that obtained with a wedge; if we were to employ fulminate of mercury in this instance, the particles of rock in the immediate vicinity of the charge would become shattered by the sudden and violent explosion, and the desired result would not be produced.

The action of gunpowder, gradual though it appears to be when compared with the action of a fulminate, may, in particular conditions, and under certain circumstances, be much too rapid. Recent investigations of the effects of gunpowder have shown that the power we possess of modifying its action so as to render it more gradual is exceedingly important. As an illustration of this, I may state that in long guns, and in cannon of large calibre, the charge of the powder used for the projection of the shot has been clearly shown to be completely ignited before the projectile is moved to any great distance along the bore of the gun; hence, we find that whenever explosions do occur in guns, in consequence, for instance, of inferior casting or metal, or an excessive charge of powder, the fracture of the gun is almost always confined to the part reaching from the trunnions to the breech. The American Dahlgren gun, of which this is a model, exhibits this great thickness at the breech end; this form has been adopted to enable the weapon to resist the comparatively enormous strain exerted on that part by the heavy charges employed. Where cast-iron cannon are still used, it will always be especially necessary, if we employ a rapidly-burning powder, to make the gun comparatively very thick from the breech towards the trunnions; and the production of strong cast-iron guns of this form is attended with very considerable difficulties; but if we use a slower powder, we can employ a cannon of more uniform thickness, as the strain exerted by the exploding powder is distributed much more uniformly throughout the greater part, if not the whole, of the length of the gun. Again, in rifled guns, in which, in consequence of the accurate fit of the projectile, the friction between it and the bore of the gun is very great, in some of which, also, as in Sir William Armstrong's gun, the projectile has to be expanded by the explosion into the grooves of the cannon, a gradually progressive action of the explosion is obviously of very great importance. In mortars and very short guns, on the other hand, where we have a very small space for the projection of the shell, it is necessary to employ a very rapidly-burning powder. It has been constantly observed that, in firing mortars with the description of powder used for cannon, a portion of the charge has been thrown out unexploded.

The explosive action of gunpowder may, however, be easily regulated in a variety of ways. We may do so, for example, by altering the composition of the powder. By increasing the proportion of the charcoal beyond that indicated by theory as the smallest quantity which will combine with the whole of the oxygen in the saltpetre, we decrease the rapidity of burning of the powder, simply because we give the saltpetre a larger amount of carbon to oxidize, which it will do less energetically; the oxidation will, therefore, take place less rapidly, and less heat will be developed. Then, again, we can modify the rate of combustion of the powder by altering the method of manufacture, — that is, by rendering the mixture of ingredients more or less perfect. And, lastly, we may modify the action of powder — and this is really the correct way of going to work — without interfering at all with the proportions of ingredients as indicated by theory, or with the intimacy of mixture essential to their perfect action, by simply modifying the state of division of the material; that is to say, by employing various sizes of grains of gunpowder, and also by submitting it to different degrees of compression. A comparison of the rate of burning of two or three different samples of powder of the same composition, but varying in size of grain, will show you that this modification in the rapidity of action of gunpowder may be effected with very great ease and nicety without interfering in any way with the ultimate amount of force exerted by the powder. Large grains, or rather lumps, have been tried, and, by employing them judiciously, it is found that they propel shot to an equal distance, and with even greater uniformity, than ordinary cannon powder. By combining the application of uniform and accurately regulated pressure with modifications in the composition of gunpowder, and by confining the material within a case or receptacle, so that, when ignited, it can only burn in one direction, the valuable arrangements known as fuses and time-fuses are obtained, by which charges of powder in shells may be ignited at any period, within certain limits, determined upon previously to the loading of the cannon. By mechanical arrangements, which regulate the amount of compressed powder to be burnt before the flame reaches the charge in a shell, the time of explosion may be adjusted with great nicety, subject, however, to slight variations which depend, as Dr. Frankland has recently shown, upon fluctuations in the density of the atmosphere. The production of rockets, signals, and numerous pyrotechnic arrangements, is based upon the principles applied in these fuses.

Although the gradual action of gunpowder is, as we have seen, of the greatest importance in most applications, there are certain instances in which more rapidly combustible substances, or more rapidly explosive bodies, undoubtedly might be employed with advantage. This is particularly the case, for example, in mining operations, where it is mainly desired to produce great destructive effects by the explosion. This circumstance has frequently led to the trial, and even occasionally to the use, for a brief period, in actual practice of bodies more readily and rapidly explosive than gunpowder. Only one explosive compound, gun-cotton, has been put to the practical test, but trials have been made of a variety of mixtures, in all of which chlorate of potash is employed instead of saltpetre, in admixture with very oxidizable substances. The preparation of any of these substances upon a large scale has, however, always been sooner or later attended by disastrous results, which in many instances have not been simply due to carelessness. Examples of these mixtures are Callow's mining powder, containing orpiment, or sulphide of arsenic, mixed with chlorate of potash, and German or white gunpowder, which consists of prussiate of potash, chlorate of potash and sugar.

We have some of these mixtures which are so prone to change as to be ignited instantaneously by contact with powerful chemical agents, such as acids, for example. Chlorate of potash is most readily acted upon by sulphuric acid, which not only decomposes the salt, but also transforms the chloric acid into very unstable compounds, and the heat resulting from the chemical changes thus established by the acid in a small portion of the mixture of chlorate of potash with an oxidizable body, such as sugar or sulphide of antimony, is sufficient to ignite it, and thus the whole is almost instantaneously exploded. Again, friction will ignite some of these mixtures very readily, as by rubbing together in a mortar a few grains of chlorate of potassa and roll sulphur. Even in the manufacture and employment of comparatively so safe an agent as gunpowder, which may be subjected without ignition to tolerably powerful friction or percussion, and to the direct application of any temperature below that which suffices to ignite sulphur (about 550° Fahr.), the neglect of strict precautions for excluding the possibility of a particle of the powder being subjected to sudden and powerful friction, may, and frequently does, lead to accidental explosions. The occasional accidents in gunpowder manufactories are generally enveloped in mystery, in consequence of their fearfully destructive effects; in all cases, however, where it has been possible to trace the causes of such explosions, they have been found in the wilful or accidental neglect of simple precautionary measures, indispensable to the positive safety of the works and operators.

The more highly explosive mixtures, and some few explosive compounds, though inapplicable as substitutes for gunpowder on account of their great sensitiveness to the effects of heat, have, in consequence of this very quality, received important applications in numerous ingenious contrivances for effecting the ignition of gunpowder. Well-known instances of such applications are, the employment of fulminate of mercury in percussion caps; of a mixture of chlorate of potassa and sulphide of antimony in arrangements for firing cannon by percussion and by friction, and for exploding shells by percussion or concussion; and of the same mixture exploded at will by being brought into contact with a drop of strong sulphuric acid, for the ignition of submarine mines or of signals.

Other mixtures, combining a high degree of explosiveness with power of conducting electricity, have been successfully applied to the simultaneous ignition of numerous charges of gunpowder by electricity of high tension; by means of one of them, recently discovered, many mines may be simultaneously discharged, even by the employment of small magneto-electric machines; the necessity for the employment of voltaic arrangements in mining operations being thus entirely dispensed with.

One of the most highly explosive mixtures at present known, consisting of chlorate of potassa and amorphous phosphorus, has been most ingeniously applied by Sir William Armstrong to the ignition of his time-fuses, and to the production of concussion and percussion fuses, remarkable for the great ease with which they are exploded. The above mixture may be ignited by the application of a gentle heat, or by submission to moderate pressure: if it is made up into a hard mass by mixture with a little shellac varnish, the friction resulting from the rapid insertion of a pin's point into the material suffices to ignite it, even when it is well covered with varnish. Thus, in Armstrong's time-fuse, which, when fixed in its place in the head of the shell, cannot, like ordinary fuses employed in smooth-bore guns, be ignited by the flame of the exploding charge of powder (as the shell accurately fits the bore of the gun), the fuse composition is inflamed immediately upon the firing of the gun, in the following manner: A small quantity of the phosphorus mixture is deposited at the bottom of a cylindrical cavity in the centre of the fuse, and over it is fixed a small plug of metal, with a pin's point projecting from its lower end. This plug is held in its place by a pin of soft metal, which, by reason of the *vis inertiæ* of the plug, is broken when the gun is fired, and the pin then instantly pierces the pellet of detonating mixture, which by its ignition sets into action the time-fuse. The distance between the pin's point and the phosphorus mixture, before the explosion, is only one-tenth of an inch. This arrangement exemplifies in a striking manner the delicacy of action which may be obtained by a judicious combination of simple mechanical arrangements and highly explosive materials.

The variety of work accomplished by the explosion of a charge of powder in an Armstrong gun loaded with a shell — no less than five distinct and important operations being thereby effected before the shell leaves the gun — affords a most interesting illustration of the progress made in the application of explosives, and of the comparatively great control which may be exercised over the operations of those destructive agents.

REPAIRING OF THE GREAT EASTERN.

In a voyage from Liverpool to New York, in October, 1862, the steamship *Great Eastern* struck upon a rock off the coast of Long Island, damaging and crushing in the iron plates on the port side for a distance of some sixteen feet. Owing to the huge dimensions of the vessel, and her inability to enter any existing dry-dock, the problem of repairing a damage of such an extent, situated some twenty-five feet below the water-line, was one not only of great engineering interest, but also one of great difficulty. Before detailing the manner in which this was accomplished, it is desirable to recall briefly the peculiarities of the vessel's construction.

The hull is formed of two distinct vessels as it were, one inside of the other. These skins are stayed to each other by a number of webs or partitions, that divide the vessel transversely into thirty-four spaces; they run the whole length from stem to stern. The webs are further crossed at right angles by thirteen separations which constitute a system of water-tight cells, each of which is entirely independent of the other, access being had to each cell through manholes, provided with plates, that open into them. It must be borne in mind also that there are, inside of the ship proper, two upright iron bulkheads that divide the hull into three long rooms. Now the man-hole plates previously mentioned communicate with each other from the upper series of cells in the ship's broadside down to the foot of the bulkhead before mentioned. There they stop. The arrangement on the other side is of course similar. The inner room has two man-hole plates on the inner skin, which allow access to the cellular divisions situated beneath it. These are connected through one another by the same plan as the others. In brief, the Great Eastern is a ship built up of a series of rectangular pipes, independent of each other, yet capable of being connected together.

Let us now return to the subject of the disaster. The fracture was entirely through the outer plating of the ship, and extended over three of the longitudinal cells. To close up the sides by any other means than with new plates was simply impossible, and these had to be put on while the vessel was in the water at her anchorage. The stubborn broken plates with their ragged edges afforded not the slightest hint that could be seized upon to accomplish the work short of much time and labor. Preliminary consultations resulted in deciding the authorities to adopt the expedient of a dam which should inclose the point of rupture on all sides, and which, by means of pumps, could be freed from water and rendered habitable while the operations were in progress.

A coffer-dam was built of heavy oak timber, semi-circular in form, and planked outside four inches thick. It was ascertained that thirty-two tons of iron would be required to sink the scow, and it was forthwith partially submerged, while two chutes, hereafter mentioned, were affixed. Previously, however, two heavy chains had been attached to each side of it, in such a manner that the cable, fastened on to the larboard side of the dam, was carried under its bottom and rendered up on to the starboard side of the main deck, and *vice versa* in respect to the other cable. From the ends representing the bow and stern of the dam there also ran large hawsers which kept it from going adrift in either of those directions. Power was then applied, and the wooden crib hove up against the ship's bottom. Around the parasitic structure were then carried other hawsers and cables, until it was firmly secured in place. Thus far matters progressed favorably — the dam was in its place, but it was full of water. Two huge chutes, or funnels, which pierced the sub-aqueous box on one side, ten feet from the ends, ran up a short distance above the water-line, and furnished the means of reaching the fracture. The edges, or gunwale of the dam, must, as will be apparent, be made water-tight, else the pumping might be continued indefinitely without any result. This it was proposed to accomplish by means of some elastic material; hence India-rubber, flock mattress, or substances of a like nature, were suggested for the purpose, but, not being available, a plan of the engineers, Messrs. Renwick Brothers of New York, was put in force.

It occurred to them that a water-hose would be just the thing. After the details of its construction — for which we have no room — had been worked up, it was soon applied, and fulfilled all the expectations formed of it. No sooner was the means discovered for obviating one trouble, however, than another appeared. This latter vexation was caused by the difficulty of overcoming the tendency which the hose had to draw in under the compartment. In order to secure it, strips of canvas were attached to one of two battens which armed the gunwale dam; these were carried under and over the hose at intervals in such a manner that the latter lay in the bight of the former; the flying end was then fixed to the batten again. Upon the outside of the case, or dam, a lappet of Brussels carpet was secured, which the water kept up against the Great Eastern's bottom, aiding materially in keeping the sea out; weeds were also thrown into whatever crevices might remain, and the projectors of this ingenious method were rewarded for all their time and trouble by its complete success. To all the unequal surfaces the water-hose opposed its soft and elastic surface, filling up cavities which could not be effectually closed by any other means. The pumps were again tried, and the crib was pumped dry. When this consummation was attained, workmen descended the chute, and in a comparatively short time replaced the plates in a substantial manner.

STRENGTH OF STEAM BOILERS.

The secretary of the Manchester (Eng.) "Association for the Prevention of Steam Boiler Explosions" in a recent report makes the following remarks on the method of ascertaining, from time to time, the strength of boilers in use. He says: —

"I know no means of ascertaining the sufficiency of the original construction of a boiler, or of testing the weakness produced upon it by wear and tear, — in short, of testing either new or old boilers, — equal to the use of hydraulic pressure, and think all steam-users would do well to make systematic use of this test once a year. In

France, I believe, this plan is rendered compulsory by the government, and it would be well were it generally adopted in this country voluntarily. Weak places in the plates may pass undetected, even on careful examination, while some parts may be inaccessible and concealed from view; but the hydraulic test is sure to detect and expose them all.

"Mr. Muntz, a steam-user in Birmingham, states that he has for years adopted, with advantage, the plan of an annual hydraulic boiler test, and considers it a duty he owes to his workmen in consideration of their safety. The application of the hydraulic test is so simple, and the pump required so small, that each steam-user could provide himself with one at a very little expense, or some parties might find it worth their while to take up the proving of boilers by water pressure as an itinerant specialty of engineering practice."

ADAMAS.

This name is given in England to a preparation of the silicate of magnesia, calcined, moulded, and baked to any required shape, and which for the last few years has been used as a substitute for metal in the manufacture of gas-burners. More recently, however, it has been applied with great success for machine bearings, and for steam and water cocks. The London *Artisan* states that a steel spindle has been run in an adamas bearing for one hundred entire days consecutively, at a speed of about fifteen hundred revolutions per minute, yet neither the spindle nor the bearing showed the slightest appearance of wear. It also states that at a large London foundry adamas is used as a fan-bearing in place of a Babbitt's patent white metal bearing, brass having been previously proved to be quite inapplicable, owing to the great friction and resulting heat; and, although the shaft makes nearly one thousand revolutions per minute, it is found that the adamas bearing remains quite cool, requires oiling but once a day, and shows no appreciable signs of wear. In the position in question the life of a Babbitt's bearing is five weeks, and it is confidently believed that the adamas will last far more than as many months.

MICA AND ITS USES.

Hitherto the use of mica has been limited mainly to the construction of stove and furnace doors, lamp chimneys, lanterns, and a few other industrial applications. Recently, however, a new field has been in the process of opening up by the endeavor to apply mica, previously colored or metallized, to the decoration of churches, rooms, shops, frames, and other ornamental and useful purposes. The mica, from its unalterable nature, preserves the gilding, silvering, or coloring from deterioration, and from its diaphaneity the articles so treated will preserve all their brilliancy. They are further preserved in a state of perfect cleanliness from the action of smoke, dust, or marks of insects, which may all be removed by washing.

Mica is prepared by Mr. Murray, of Paris, for ornamental purposes as follows: — It is first cut to the desired thickness, then coated with a thin layer of fresh isinglass diluted in water, and the gold or other surface applied, after which it is allowed to dry. The sheet of mica can be easily rendered adherent to almost any article by glueing. Mr. Murray then takes a pattern of copper, with a design cut out on it, and places it on the reverse side of the mica, and with a small brush removes any superfluous parts, the required design thus remaining on the parts which have not been brushed. He then applies colors, either one or more times, as considered necessary, and afterwards coats the whole with a solution of liquid glue diluted in spirits of wine, which is applied for the purpose of rendering the mica pliable. When this is effected, the mica with the design upon it is applied to the frame of the other object and fastened with glue. In order to make the junctions of several pieces of mica imperceptible, Mr. M. first glues them together with Venetian glue, and then applies a hot iron to the parts where the mica is joined together, when the parts will be completely united.

The value of mica depends upon the size of the sheets and their transparency, the clear ruby-tinged being the finest, and the cloudy gray the least valuable. The best mica in the English market is now imported from Calcutta and Siberia, and is at present readily salable at from 60 cents to $1.00 per pound.

CHROMO-TYPOGRAPHY.

Although block books in colors are as old as printing in China, pictorial printing in oil-colors on the platten and cylinder press is a thing of the present day. Such, however, has been the rapid development of this art, that prints on which twelve colors are required are now thrown off with the rapidity of newspapers on a steam-press. The well-known colored prints which accompany the London *Illustrated News* are specimens of this style of chromo-typography; and so great is their beauty and popularity that of some favorite issues two hundred and fifty thousand copies have been struck off

ADHESIVE STRENGTH OF GLUE.

At the International Exhibition, 1862, a manufacturer of glue showed a wooden bar, having a sectional area of one square inch, sawn across and united by glue. This joint resisted a tensile strain of five hundred and four pounds.

INGENIOUS PLAN OF CORRESPONDING IN CIPHER.

The New York *Evening Post* states that the following mode of corresponding in cipher has been devised and used during the present civil war: — Each correspondent is provided beforehand with a page printed from the same form, which may be any connected article in a book or paper, or merely the several letters of the alphabet arranged in parallel lines with the more common letters repeated a proper number of times. Then the correspondent who writes to his friend lays his sheet over a sheet of white paper and punches out the letters to spell his words, driving the punch through the sheet below. The white sheet is then forwarded to the correspondent, who lays it over his printed sheet, and spells out the words which are formed by the letters seen through the holes, and which of course correspond with those punched out of the other sheet. Should the dispatch be found on its way, it is of course nothing more than a sheet of white paper punched with holes, conveying no intelligence without the printed sheet.

NEW USES FOR PAPER.

The village of Wallsend, England, is lighted with gas conveyed through pipes made of paper bituminized. These pipes possess great strength, durability, and inoxidibility, with the advantage of being about one-fifth the weight of iron pipes, and about thirty-five per cent. cheaper. The process of the manufacture consists in causing a roll of paper to pass through a reservoir of melted bitumen, after which it is tightly coiled round a mandril to any required thickness; thus, when hardened, a tube of perfect texture, great hardness, and enormous strength, is formed. These pipes are also to be used in laying about five miles of the gas pipes in Sunderland; and there is every probability that they will speedily come into general use.

At the International Exhibition, London, 1862, paper pipes made water-proof were exhibited, which were warranted to endure a pressure of one hundred and sixty pounds per square inch, and to be indestructible by ordinary influences, either under ground or in open air. The same exhibitor also showed paper boards, prepared in the same way as the pipes above mentioned, which he stated were much stronger and only half the price of oak. They could be made of any thickness or size, and were applicable for the construction of stables, outhouses, sheds, pontoons, gunboats, etc. Messrs. Green & Co., of Cork, Ireland, exhibited brown paper prepared for roofing, rendered impenetrable to water by tar, of low cost, and warranted to wear for twenty years.

COMPRESSED COAL.

The question of the compression of coal has engaged the attention of mechanical and scientific men for many years, the great difficulty having been to bring about the desired result without the admixture of extraneous cohesive matter. By the amalgamation of several inventions, an English company — according to the London *Mining Journal* — have at last reached the coveted goal, being able to compress the finest coal into blocks which occupy two-thirds the space of ordinary coal, taking but thirty-one cubic feet to the ton, while raw coal averages from forty-four to forty-eight feet. The process by which these compressed blocks are obtained, says the Journal, is inexpensive, and without complication. In the first place, the pure coal-dust, or slack, is conveyed through a washing machine, for the purpose of disconnecting it from any stony particles it may contain. It is then subjected to a steady heat, until its bituminous parts are rendered quite soft, after which it is passed into a moulding machine. This comprises a rotary table containing the moulds, around which are situated three presses — namely, the feeder, for filling the mould; the main press, for condensing the block; and the discharger, which removes the block out of the mould, whence it falls into a travelling web, which carries it away. The presses act simultaneously, and between every stroke the table makes one-third of a revolution, by which the coal is removed from one press to the other. An apparatus is provided for extracting the gases from the coal during pressure, ingeniously opening out the air-passages at each stroke, which would otherwise become choked by the bitumen. In these presses, necessarily of a very powerful description, breakages would be always occurring but for a provision which has been made, by the fulcrum of the levers of the main press resting on the ram of a hydraulic press, the safety-valve of which is loaded only to the extent that the strength of the machine will bear. Each machine, which is inexpensive in construction, is capable, it is calculated, of making twenty-eight tons per day, at an estimated cost of two shillings per ton. From having, during the process of washing, the stony parts removed, and from the lighter gases which produce smoke being driven off during the manufacture, it is said that steam vessels provided with these blocks of compressed coal will carry fuel for steaming nearly double the number of days; and, moreover, that this fuel is free from the danger of spontaneous combustion.

COMPRESSED BREAD.

To replace the indigestible hard biscuit used in the French army and navy, a preparation of compressed bread has been recently introduced. Small loaves baked in tins are thoroughly dried and then pressed into cakes (four inches square and three-quarters of an inch thick) by a machine invented and patented by M. Marinoni, of Paris. The cakes recover their original dimensions when put into water.

ORNAMENTAL BURNT WOOD-WORK.

The following mode of producing ornamental wood-work by burning is now practised in London. Designs in relief are engraved on the face of hollow iron cylinders; and these, being heated by a gas-pipe within, acted on by a second pipe conveying atmospheric air, are made to transfer these designs to the planed board which is passed in between them as they revolve. When the wood has gone through the charring operation, it is handed to a workman, who scrapes it down over the surface so as to bring out the lights and produce the best effects. This being accomplished, the face is varnished or polished, and the result is an ornamental panel or moulding of considerable beauty (*if the design be good*), and of remarkable permanence. White woods, as sycamore or lime, are employed for the work. It is easy, also, by this process, to give to the less expensive varieties of wood the characteristic of the more costly kinds. Rosewood and walnut are very well imitated, and upon these any pattern can be impressed. The cost of woods imitated in this way is put at two-thirds the cost of good hand "graining."

IMPROVED BOLT.

Messrs. Lawrence and White, of Melrose, N. Y., have recently patented an improved bolt, which has all the excellency of the rivet, with this advantage over a rivet, that when required it may be moved from its place without any trouble. It is well adapted for the framework of locomotives and railway carriages. The bolt passes through an iron frame, or through wood-work, and is secured behind by a nut. But inasmuch as a nut is liable to be unturned in the extremity of the thread of the screw-bolt by vibration, and as many railway accidents have happened from the fact of bolts having parted for the want of their retaining nuts, in the present case the nut is kept in its place by having a spring inserted into it, which adapts itself to the ratchet-work of a hollow washer.

NEW SEA-ISLAND COTTON-GIN.

The ginning of sea-island cotton has always been a difficult mechanical achievement; the ordinary cotton-gin of Whitney injuring the long and delicate fibres too greatly to admit of its use. A gin, known as Brown's Excelsior gin, invented in 1858, but recently introduced for use, seems to overcome all the difficulties heretofore experienced by inventors in this department. It consists of a single roller, a steel breastplate, and a vibrating stripper, by which the seeds are thrown down behind and through a grating, while the cleaned cotton is delivered in front. To present some idea of its construction and operation, we will state that it closely resembles a box about three feet in height, three feet in width, and the same in length. In front and on the top is a leather-covered wooden roller, about five inches in diameter, and thirty-six inches in length. The leather with which it is covered is formed of strips two inches in width, wrapped spirally around it, tacked down at the edges, and bevelled so as to form a spiral groove from end to end. Behind this roller is a steel breastplate, closely resembling a broad and long shaving-knife of exquisite and peculiar temper. The edge of this plate presses close against the back of the roller, and above it, extending across, is a vibrating or stripping bar, which plays up and down like the crosshead of a saw-gate. Behind this is the feed-board, which has an iron grating situated close to the breastplate. The uncleaned cotton is placed on the feed-board, and is pressed forward in a stratum by the girl that attends the gin. The machine is driven by band and pulley, the roller rotates downward toward the steel breastplate, and draws the fibre of the cotton between the roller and the steel plate. There is not sufficient space for the seed to pass through between the roller and the breastplate scraper; therefore the seed is left behind, and the vibrating stripper strikes down upon it, executing a series of small blows which knock off the seed, driving it through the grating, and into a receptacle below the feed-board. The uncleaned cotton goes into the gin behind, a mass of black and white knots; it comes out in front a beautiful, white, silky-looking fibre. A cord is stretched in front from side to side across the roller, to prevent the cotton from being carried around and clogging the gin. When a gin is first started, the ginned cotton drops from the roller freely, but after running for a short period the roller becomes so positively charged with electricity, that the cotton is attracted to it, and would be carried round and round but for the stripping-cord in front. One of these gins will clean from two hundred to two hundred and fifty pounds of cotton per day, in a superior manner, but it can also be run to clean five hundred pounds. — *Scientific American.*

CORK-CUTTING MACHINE.

A cork-cutting machine, recently invented by Mr. Conroy, of Boston, Massachusetts, has the following construction and method of working. A suitable apparatus first cuts the cork into parallelopipedons, and then into smaller figures of the same kind, according to the length of bung or cork required. These smaller pieces are brought in contact with a knife mounted on a circular horizontal disc. The disc is put in motion by a large wheel similar to a cutler's wheel, and a band running over a drum in immediate connection with it; or it may be worked by steam-power. This disc, by means of gearing, traverses a platform from right to left, and *vice versa*, by which arrangement a cork is no sooner cut on one side than a cork is cut on the other. The square body to be shaped into a rounded one is placed in a groove; the gearing seizes it in the manner of a piece of wood in a turning-lathe, by its extremities, advances it to the edge of the circular knife, and in an instant the rough block of cork appears a shaped article wherewith to stop a beer barrel, a bottle of champagne, or a medicine vial. The ease with which this machine does its work is surprising. A clever cork-cutter, working by the hand, can turn out, on the average, eight gross of corks a day. By this machine can be made fourteen gross of corks per hour. In a day of ten hours, therefore, two men can produce 20,160 corks or bungs, while two men by the hand, in the course of the same time, can turn out only 2,304. The corks can be cut in perfect cylinders, or bevelled to any angle required by slightly elevating the horizontal disc. The machinery is very simple, and ingenious through its simplicity.

PERFUME VAPORIZER.

A simple apparatus, capable of being made very useful as a sanitary agent, as well as for the diffusion of merely pleasant odors through apartments, hospitals, halls, theatres, etc., has been invented by Mr. E. Rimmel, an English perfumer. It consists of a vessel heated by a small lamp below it, and intended for the vaporization of steam impregnated with the odors of flowers, aromatic vinegar, or acids, chlorine, ammonia, etc. Some perfumes act not merely as ministrants to luxury or pleasure, but as sanitary agents, by, it is believed, ozonizing the oxygen of the atmosphere, and so converting it into true *vital* air; and one essential oil, namely, oil of cloves, though heavy as a mere perfume, has a very singular power of destroying musty mould, as in paste or gum, and of keeping it sweet and fresh for months. Such an agency, diffused by Rimmel's vaporizer, in close and musty apartments, could not but sweeten them. The choice of perfumes, however, is endless. Dr. Hassall, who recommends this apparatus as a useful sanitary agency, states that if even the delicate flower-leaves of the violet or rose be thrown into the vaporizer, their scent will be diffused throughout a room, without any of that acrid and offensive empyreumatic odor which is so apt to accompany the *combustion* of perfumes, as on the burning of incense or pastilles.

PRESERVING TIMBER.

M. Lapparent, naval constructor in the French navy, in a recent essay on the preservation of timber, advocates charring its surface as the most effectual way of securing it from rot for a long period. He says: — "By charring timber the surface is subjected to a considerable heat, the primary effect of which is to exhaust the sap of the epidermis, and to dry up the fermenting principles; in the second place, below the outside layer, completely carbonized, a scorched surface is found, that is to say, partly distilled, and impregnated with the products of that distillation, —viz., creosote and empyreumatic oils, — the antiseptic properties of which are well known. A bench, the legs of which had originally been charred to the depth of nineteen inches, after remaining in the ground eighteen years, near a pond, was dug up, and found to be in such good preservation that it was difficult to get the point of a knife into the extreme end of one of the legs. On the other hand, vine props of oak, driven into the dry soil close by, were rotten in one year." M. Lapparent's method, which is now applied in the French dock-yards, consists in subjecting the timber to a slight carbonization, by means of a jet of common coal-gas. A workman, says M. Lapparent, can, in an average day's work of ten hours, carbonize a surface of four hundred and forty square feet. In shipbuilding, gas-charring should be applied to every surface likely to be in contact with moist or stagnant air. In house-building, it should be applied to the beams and joists embedded in the walls or surrounded with plaster; to the joists of stables, cow-houses, and laundries, which are affected by a warm, moist atmosphere; and to the wainscotting of ground-floors. For railway-sleepers, charred timber, when scraped, can be painted any color.

NATURAL PHILOSOPHY.

THE NATURE OF FORCE.

The following abstract of a lecture recently delivered before the Royal Institution, London, by Professor Tyndall, presents most clearly some of the remarkable facts that have been recently developed respecting the nature and correlation of mechanical force and heat. A substance suspended at a height of sixteen feet above the earth's surface, and allowed to fall, reaches the surface in one second of time, its velocity, which has been regularly accelerated, being then at the rate of thirty-two feet per second. Suppose that, instead of being pulled downward by gravity, the weight is cast upward in opposition to the force of gravity, with what velocity must it start from the earth's surface in order to reach a height of sixteen feet? With a velocity of thirty-two feet a second. This velocity imparted to the weight by the human arm, or by any other mechanical means, would carry the weight up to the precise height from which it has fallen.

Now, the lifting of the weight may be regarded as so much mechanical work. I might place a ladder against the wall, and carry the weight up a height of sixteen feet; or I might draw it up to this height by means of a string and pulley, or I might suddenly jerk it up to a height of sixteen feet. The amount of work done in all these cases, as far as the raising of the weight is concerned, would be absolutely the same. The absolute amount of work done depends solely upon two things: first of all, on the quantity of matter that is lifted; and, secondly, on the height to which it is lifted. If you call the quantity or mass of matter m, and the height through which it is lifted h, then the product of m into h, or mh, expresses the amount of work done.

Supposing, now, that instead of imparting a velocity of thirty-two feet a second to the weight, we impart twice this speed, or sixty-four feet a second; to what height will the weight rise? You might be disposed to answer, "To twice the height;" but this would be quite incorrect. Both theory and experiment inform us that the weight would rise to four times the height; instead of twice sixteen, or thirty-two feet, it would reach four times sixteen, or sixty-four feet. So, also, if we treble the starting velocity, the weight would reach nine times the height; if we quadruple the speed at starting, we attain sixteen times the height. Thus, with a velocity of one hundred and twenty-eight feet a second at starting, the weight would attain an elevation of two hundred and fifty-six feet. Supposing we augment the velocity of starting seven times, we should raise the weight to forty-nine times the height, or to an elevation of seven hundred and eighty-four feet.

Now, the work done, — or, as it is sometimes called, the mechanical effect, — as before explained, is proportional to the height, and as a double velocity gives four times the height, a treble velocity nine times the height, and so on, it is perfectly plain that the mechanical effect increases as the square of the velocity. If the mass of the body be represented by the letter m, and its velocity by v, then the mechanical effect would be represented by $m\,v^2$. In the case considered, I have supposed the weight to be cast upward, being opposed in its upward flight by the resistance of gravity; but the same holds true if I send the projectile into water, mud, earth, timber, or other resisting material. If, for example, you double the velocity of a cannon ball, you quadruple its mechanical effect. Hence the importance of augmenting the velocity of a projectile.

The measure then of mechanical effect is the mass of the body multiplied by the square of its velocity.

Now, in firing a ball against a target, the projectile, after collision, is often found hissing hot. Mr. Fairbairn informs me that in the experiments at Shoeburyness it is a common thing to see a flash of light, even in broad day, when the ball strikes the target. And if I examine my lead weight after it has fallen from a height, I also find it heated. Now, here experiment and reasoning lead us to the remarkable law that the amount of heat generated, like the mechanical effect, is proportional to the product of the mass into the square of the velocity. Double your mass, other things being equal, and you double your amount of heat; double your velocity, other things remaining equal, and you quadruple your amount of heat. Here, then, we have common mechanical motion destroyed and heat produced. I take this violin bow and draw it across this string. You hear the sound. That sound is due to motion imparted to the air, and to produce that motion a certain portion of the muscular force of my arm must be expended. We may here correctly say that the mechanical force of my arm is converted into music. And in a similar way we say that the impeded motion of our descending weight, or of the arrested cannon ball, is converted into heat. The mode of motion changes, but it still continues motion; the motion of the mass is converted into a motion of the atoms of the mass, and these small motions communicated to the nerves produce the sensation which we call heat. We, moreover, know the amount of heat which a given amount of mechanical force can develop. Thus, for example, the force of a leaden ball falling sixteen feet is sufficient, if suddenly arrested, to raise its temperature three-fifths of a degree Fahrenheit. Its velocity, when arrested, at the end of the sixteen feet, was at the rate of thirty-two feet a second; but a rifle bullet has at least forty times the velocity of a body falling for one second; hence, when suddenly arrested, as by an iron target, the heat generated, provided it could be concentrated in the bullet, would raise its temperature to about nine hundred and sixty degrees, — sufficient to melt the lead. In reality, however, the heat developed is divided between the lead and the body against which it strikes; nevertheless, it would be worth while to pay attention to this point, and to ascertain whether rifle bullets do not, under some circumstances, show signs of fusion.

The conversion of muscular force into heat is strikingly shown in the concussion of flint and steel, as in the old method of obtaining a light. Energetic chemical union is always attended with the evolution of heat, which may be regarded as being produced by the falling together of atoms at a high velocity. The heat so evolved can be made to reproduce the exact amount of force that was arrested in its production. The burning of charcoal in oxygen is an old and familiar experiment; but it now has a significance beyond what it formerly had, inasmuch as we may now regard the act of combination on the part of the atoms of oxygen and coal exactly as we regard the clashing of a falling weight against the earth. And the heat produced in both cases is referable to a common cause. This glowing diamond, which burns in oxygen as a star of white light, glows and burns in consequence of the falling of the atoms of oxygen against it. And could we measure the velocity of the atoms when they clash, and could we find their number and weight, multiplying the mass of each atom by the square of its velocity, and adding all together, we should get a number representing the exact amount of heat developed by the union of the oxygen and carbon.

Thus far we have regarded the heat developed by the clashing of sensible masses and of atoms. Work is expended in giving motion to these atoms or masses, and heat is developed. But we reverse this process daily, and by the expenditure of heat execute work. We can raise a weight by heat, and in this agent we possess an enormous store of mechanical power. Thus, the union of a pound of coal with about two pounds of oxygen evolves an amount of heat capable, if properly applied, of raising a hundred pounds' weight to a height of twenty miles. The coal raised every year in England amounts to 84,000,000 tons, which, were they all applied to the production of force, would be equal to 108,000,000 horses working constantly: or a pound of coal may be regarded as equal to the force of three hundred horses working for one minute. Conversely, one hundred pounds falling from a height of twenty miles, and striking against the earth, would generate an amount of heat equal to that developed by the combustion of a pound of coal. Wherever work is done by heat, heat disappears. A gun which fires a ball is less heated than one which fires blank cartridge. The quantity of heat communicated to the boiler of a working steam engine is greater than that which could be obtained from the recondensation of the steam after it had done its work; and the amount of work performed is the exact equivalent of the amount of heat lost.

The fact that force may be converted into heat has given rise to a theory which attributes the light and heat evolved from the sun to the falling of meteoric bodies on to its surface. Of the amount of heat produced by this luminary some idea may be gained from the fact that the earth receives only $\frac{1}{2300000000}$ part. Moreover, it is calculated that the heat given out by the sun every minute is sufficient to boil 12,000,000 cubic miles of ice-cold water. This vast amount of heat is supposed by Dr. Mayer, of Heilbron, to be due to the falling into the sun of meteorites. The objection to the theory that these bodies are too few in number is met by the fact, that at one observatory alone as many as 240,000 have been observed in nine hours.

Meteoric bodies attracted by the sun would necessarily move with a high and rapidly accelerating velocity, and it is calculated that a body falling into the sun at a velocity of three hundred and ninety miles a second would attain a temperature nine thousand times that produced by the combustion of coal. A body the size of the earth falling into the sun would supply its heat for about one hundred years, but would make no appreciable increase in its bulk; and were the earth's motion suddenly arrested, the heat developed would raise the temperature to such a degree that the elements would be dissipated in vapor. Notwithstanding the difficulties in the way of receiving this theory of Dr. Mayer's, it was regarded by Dr. Tyndall as that which offered the best explanation of the cause of solar heat.

PERMANENCE OF THE SOLAR SYSTEM.

One of the most interesting questions which have arisen from the investigations of modern science into the general laws of nature is that of the stability of our universe as at present constituted. Is this system fitted to run on forever, in accordance with its present laws, or will these laws, in the end, lead to its subversion? The conclusion was reached by Laplace, and has been confirmed by subsequent investigators, that, so far as the force of gravitation alone is concerned, the system is stable. Every change which the attraction of one planet produces in the orbit of another will finally induce its own compensation, and bring the system back to its original state. But the discoveries of the present century respecting the correlation of the different forces of nature, the conservation of force in general, the nature of the solar light and heat, and the motions of the comets, seem to indicate that gravitation is by no means the only force by which the motions of the heavenly bodies are influenced, and that causes which slowly but surely undermine the system are in operation: that the latter is not, therefore, a self-winding clock which may run forever, but that it must ultimately lose all motion, unless some power, capable of controlling the laws of material nature, shall interfere to preserve it. We shall give some examples of these destructive forces.

In the first place, the sun is radiating heat into space in quantities incomparably greater than it receives. If it were not so, we should receive on the average as much heat from every other quarter of the heavens as from the sun, and no vicissitudes of temperature could ever occur on earth. From what we know of the nature of heat, it is impossible that the supply contained in the sun should be absolutely infinite. The sun must, therefore, as centuries advance, grow cooler and cooler, until its heat is entirely lost. This will be followed by the cooling of the earth, and thus all life on our planet must cease, or the conditions of its existence must be completely changed. It may be asked, Is it certain that the heat of the sun is not returned to it in some other form? It is, of course, impossible to give any absolute and direct proof that the sun does not receive heat, or its equivalent, from some unknown source; but it is certain that we can trace the operation of no natural law which would tend to return heat to the sun, and that the existence of any such operation seems improbable. It has been suggested that the sun may be supplied with fuel by comets or other bodies falling into it.

Another element of destruction probably exists in the form of a very rare resisting medium in space, whose existence, however, has not yet been demonstrated with certainty. Yet there is evidence in its favor. There is no reason *a priori* why we should suppose the planetary spaces to be perfectly void; on the contrary, the general analogies of nature would lead us to suppose that they still contain something material. Now, there are two classes of phenomena which point to the existence of an ether, filling all space, and possessing the property of inertia. These are as follows: The phenomena of light and heat. These seem to be due to a vibratory or oscillatory motion among the molecules of an ethereal medium. By the heat-vibrations, force may be communicated from one body to another, distant and having no material connection with it; it is, therefore, concluded that ether is possessed of the property of inertia. In our ignorance of the exact nature of its motion, and the amplitude of its vibrations or oscillations, we have not sufficient data for determining the density of the hypothetical medium. But this density, however small, must be appreciable, and therefore retard the motions of all bodies moving through it.

The observations of Encke's comet made during the last thirty or forty years show that its motion is continually undergoing acceleration[1] from some cause, and that, if this continues, it will in a few centuries fall into the sun. This comet, being a small nebulous mass of excessive tenuity, is precisely the object which would be most affected by a resisting medium, and Encke attributes its acceleration to this cause. His view is controverted by other astronomers, some of whom attribute the anomalies of the comet to the repellant action of the sun in driving off the comet's tail — a subject to which we shall presently revert. In view of these controverted points, it will be hardly fair to consider it certain that the motions of the planets will ever be affected by the ether, especially as it is possible that, even if the ether exists, it may not affect their motions.

Yet another cause, slowly producing an entire change in our earth, is found in the mutual action of the moon and the tide-wave. As the latter glides over the oceans, and rushes into the numerous indentations of the coast, the motions which it produces in the waters necessarily involve an expenditure of power, or *vis viva*, in overcoming the effects of friction. This *vis viva* thus expended must be drawn from the set of machinery which produces the motions, that is, from the motion of revolution of the moon and the motion of rotation of the earth. It cannot be returned to this machinery, because all that is not spent in triturating the sand or other material which forms the bed of the ocean is turned into heat, and radiated off into space. Its loss will manifest itself in exactly the same way in which a resisting

[1] It may appear paradoxical that a resisting medium should cause the motion of a body moving through it to be accelerated. It produces this effect indirectly. If the medium retards the body by the smallest amount, the latter will fall slightly toward the centre of attraction, and the increase of velocity caused by this fall will more than compensate for the retardation which produced it.

medium would take effect; that is, the motion of revolution of the moon will be accelerated, and the rotation of the earth retarded, till the day and the lunar month become equal.

The action of such a cause is traceable in the rotation of the moon on its axis. It is well known that our satellite has always, since the earliest records of its appearance, presented the same face to the earth. It is in the highest degree improbable that its rotary motion was in the beginning exactly adjusted so as to produce this effect. But if the moon were liquid, or covered by a liquid, the immense tides produced by the earth would in time produce the effect which we now see. The hypothesis that the equality in the times of revolution and of rotation of the moon is to be attributed to this cause, derives additional strength from the fact that the satellites of Jupiter seem to follow the same law. This equality, once established, will continue forever. In consequence of the acceleration of the moon's motion, and the consequent diminution of the lunar month, she will, in a few thousand years, be half a month ahead of the place in which she would be if her month were to remain constant, and will, therefore, be on the opposite side of the earth. If her time of rotation remained constant during that period, the side which is now hidden would then be presented toward the earth, so that our posterity of two hundred centuries hence would have an opportunity of unveiling its mysteries. But analysis has answered the question for them, and demonstrated to us that the hemisphere of our satellite, which is now turned from the earth, will so remain, hidden from mortal eyes, to eternity.

Viewing the system of the world, then, with the aid of all the light that can be thrown on it by science and by philosophy, selecting the most probable causes for those phenomena of nature which we cannot deduce from the known general laws of the universe, and tracing these and all known causes to their most remote and latent effects, — making at every step all due allowance for our ignorance, and giving proper weight to every sound philosophical principle which bears on either side, — there seems to be a decided preponderance of evidence in favor of the doctrine that this system is not entirely self-sustaining and self-compensating, but is subject to actions which must lead to its ultimate subversion. — *North American Review.*

THE ELECTRIC LAMP IN LIGHTHOUSES.

For the last five or six years the maritime world has been waiting with some anxiety for the termination of some experiments respecting the employment of the electric light as a beacon. These experiments are well-nigh concluded, and the question whether the old oil-lamp is to be superseded by the electric lamp will be speedily determined.

Early in 1857, experiments were made on the subject by Prof. Faraday and Prof. Holmes, and subsequently the latter was requested by the Trinity House to prepare a plan for employing the new light. This plan was submitted to Prof. Faraday, who reported favorably upon it, and the result was that the Trinity Board sanctioned the establishment of an electrical apparatus in the South Foreland Upper Lighthouse. This apparatus consisted of an accumulation of powerful magnets and iron cores with surrounding coils, accurately arranged, so that when the associated cores were revolving they sent all their currents into one common channel, from whence they were conveyed to the lantern by conducting wires, and there produced the electric light. There was no consumption of material or energy, other than that of the burning fuel required at the steam engines to produce motion.

A trial of the light began in the lighthouse on the 8th of December, 1858; but as the apparatus was imperfect in some points, and the results unsatisfactory, the lighting by the apparatus was suspended for a while, that the defects might be remedied. The lighting was renewed in March, 1859, and during the following month it was carefully examined by Prof. Faraday. In his subsequent report to the Trinity Board, after describing very fully the observations he made at sea, and the various experiments by which he tested the power of the light, he states his opinion that Prof. Holmes had practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned; that the light produced was powerful beyond any other that he had seen so applied, that its regularity in the lantern was great, and its management easy. Ten months after he had thus expressed his approval of the experiment, he again visited the light, and found it of the same character as when he had last seen it. It was generally very steady, but with slight interruptions now and then from iron in the carbons. He found that it had a tendency to sudden and spontaneous extinction, arising either from the breaking off of the end of the carbon, or from some disarrangement in the fine mechanical work of the lamp. This happened three or four times every night; and being once extinguished the lamp did not relight of itself. The slightest touch of the keeper's hand, however, was enough to restore the light; but the liability to temporary extinction occasioned an anxious watchfulness on the part of the attendant, who was constrained on this account to stay in the lantern continually. The light had never been stopped by any deficiency of action in the machine-room.

The appointed time during which the magneto-electric light was to be placed under practical trial at the South Foreland having, early in 1860, come to an end, Prof. Faraday urged the Trinity House to authorize its application, either there or somewhere else, for a further and a longer period, stating that it had proved to be practical and manageable, and had supplied the means of putting into a lighthouse lantern, for six months or more, a source of illumination far surpassing in intensity and effect any other previously employed. Acting on this suggestion, the Trinity Board established an electric light at Dungeness. At this lighthouse it is placed in an optic apparatus constructed especially for it, which is only sixteen inches in height, and fourteen inches in external diameter. The apparatus consists of six lenticular zones and seven reflecting zones; of the latter three are below and four above. At the South Foreland there was one electric lamp placed in the centre of a Fresnel optic apparatus. Here there are two of the new optic apparatus, placed one over the other in the axis of the lantern, and four electric lamps: for each apparatus two, only one lamp being used at a time. Mr. Holmes includes in his plan the use of all these lamps and apparatus, because of the facility of rapid change in the lamps and carbons, and they cause no alteration in the magneto-electric machines, wires, or engines, which are the same as were employed at the South Foreland.

Beside the electric apparatus, the light from which passes through the upper panes of the lantern, the original reflectors and their lamps are retained in place, so that they can be at once substituted for the electric light if any accident or failure should occur to the latter, and also may be used in conjunction *with* the electric light in a comparison of one with the other.

In one of his reports on the Dungeness light, written during the past year, Prof. Faraday mentions an interesting experiment. Arrangements were made on shore (Mr. Holmes being in charge of the light), by which observations could be taken at sea about five miles off, on the relative light of the electric lamp and the metallic reflectors with their Argand oil lamps. At the given distance the eye could not separate the two lights, but by the telescope they were distinguishable. The combined effect was a glorious light up to the five miles; then, if the electric light was extinguished, there was a great falling off in the effect; though, after a few moments' rest to the eye, it was seen that the oil lamps and reflectors were in their proper state. On the other hand, when the electric light was restored, the illumination became again perfect.

Then, whilst both were in action, the reflectors were shaded, and the electric light left alone; but the naked eye could see no sensible diminution; nor when the reflectors were returned into effectual use could it see any sensible addition to the whole light power, though the telescope showed that the alteration in the lantern had taken place at the right time. Such was the power of the electric light, that the addition or subtraction of the light of a fully effective set of reflectors, with their lamps, would not have been sensible to a mariner, however observant he might have been.

Prof. Faraday enumerates some points which are against, and others in favor of, the light. In the first place, the simplicity of the present system is very great, compared with that of the electric light: only two keepers are required to a lighthouse; they need possess no special knowledge; ordinary attention is all that is necessary; and thus failures of the light are almost impossible. In the new system a second set of men will be required to attend the engines, and there must be among them one or more who understand the principle and construction of the lamp in the lantern, of the magneto-electric machines, the steam-engines and the condensers, and be able to make effectively the repairs necessary to the apparatus. In the next place, the expense of the new system must be large compared with that of the present system. Other objections have been made, of which Prof. Faraday cannot see the force; namely, that the light is too bright, — that it gives a false impression of the distance of the lighthouse, — and that it blinds the eyes of the mariners to the perception of the lights on board vessels between it and them. These objections, he says, if they have any force, must be judged by mariners themselves.

The points in favor of the magneto-electric light are strong and clear in relation to the increase of light. In cases where the light is from lamp flames fed by oil, no increase of light at or near the focus or foci of the apparatus is possible beyond a certain degree, because of the size of the flames; but in the electric lamp any amount of light may be accumulated at the focus and sent abroad, at of course an increased expense. In consequence of the evolution of the light in so limited a focal space, it may be directed seaward, diverging either more or less, or in a vertical or horizontal direction, at pleasure, with the utmost facility. The enormous shadow under the light produced by the oil-flame burner, which absorbs and renders useless the descending rays to a very large extent, does not occur in the magneto-electric lamp; all the light proceeding in that direction is turned to account; and the optical part of the arrangement, whether dioptric or reflecting, might be very small in comparison with those in ordinary use.

COLLIER AND BAKER'S IMPROVEMENTS IN THE ELECTRIC LIGHT.

At a recent meeting of the Franklin Institute, Mr. A. L. Fleury called attention to a magneto-electric machine invented by Messrs. Collier & Baker, of Binghampton, as being the best adapted for all purposes for which a large quantity of dynamic as well as static electricity is required, and as especially applicable for the production of the electric light.

The invention consists, first, in certain means of controlling the positions of the electrodes, by which they are kept properly in contact with each other, as they wear away by the disengagement of the particles, without the difficulty experienced in keeping up a proper degree of separation between them. To produce a light in this way has generally been supposed to be impracticable; but the inventors, by long-continued experiment, have found that by employing an electric current of very low intensity, but large quantity, they are enabled to use the points in contact. The difficulty of keeping the carbon electrodes pointed has resulted from particles of carbon being carried over by the current of electricity from the positive to the negative pole of the electrodes. With a view to obviate this (viz., the depositing of particles from the positive on to the negative pole), the invention also consists, secondly, in frequently reversing the direction of the current. To obtain this change of direction, the current of electricity evolved from a magneto-electric machine is used without the intervention of a frotteur or brake-plate, or else the current from a galvanic battery can be used — there being arranged in the circuit a brake-plate or pole-changer, which is rotated by electricity, by clock-work, or by any suitable mechanical means to produce a frequent change in the direction of the current. This invention, dispensing with expensive machinery, is a valuable contribution to applied science, and will do much towards rendering this most brilliant light available.

In the production of electric light, preference has generally been given by scientific men to the employment of carbon electrodes, and these mostly in the shape of pointed pencils, as giving the most brilliant and desirable light; but so much difficulty has been heretofore experienced in securing the proper relative positions of the pencils, and in keeping them pointed, that electricians have been forced to very ingenious, but expensive and often complicated, mechanical appliances to obviate these the only apparent objections to the use of the desired carbon electrodes.

Any one who has examined the complicated mechanism of former electric lamps must be struck with the remarkable simplicity and perfection of the apparatus originated and constructed by the Messrs. Collier & Baker, which secures most accurately the adjustment of the carbon points. Dispensing with all gearing, springs, screws, electro-magnetic regulators, or other complications, its simplicity is only equalled by an ordinary candlestick, and its appearance is about as unassuming.

The main feature of this lamp is a hole in a metallic strap or bridge, which secures the position of the points, and regulates the feed or supply as fast as consumed. The carbon pencils being in vertical positions, the upper one is fed down by gravity, and the lower one as a float is fed up by its own buoyancy. The hole or orifice in the upper metallic strap or bridge is of a diameter a *little less* than the body of the pencil, so as to permit a portion only of the point to pass through, and as fast as it is reduced in size by the oxidation and disengagement of particles during the process of combustion. The pencil is thus gradually and surely fed downwards, and the feed regulated and controlled by its own combustion.

Using an electric current of *large volume and low intensity*, as the Messrs. Collier & Baker much prefer, the electrodes may remain *in contact;* then the hole in the lower strap, being the same size as the body of the lower pencil, acts as a perfect guide to the pencil as it passes up through it, and the lower pencil, resting its point against the point of the upper pencil, is thereby controlled in its feed upwards. Using a current of *high* intensity, it being desirable to *separate* the points and maintain that distance, the feed of the lower pencil is regulated and controlled by reducing the size of the hole in the strap to correspond with the upper one, and for the same purpose, using a current of electricity constant in one direction, there is a tendency to an accumulation of particles of carbon on the negative electrode, and a consequent blunting of that point. To avoid this, Messrs. C. & B. use a *to-and-fro* current. In this invention, the extremes of simplicity and cheapness are combined, — the cost of the lamp being but a few dollars.

There can be little doubt, adds Mr. Fleury, but that the application of magneto-electric machines for the production of light, and for all purposes where a large amount of electricity is required, will soon supersede the use of galvanic batteries. A few words relative to the importance of this machine for the *ordinary telegraph* may here not be amiss: —

The extent of telegraphs in the United States is increasing every day; the capital involved is upwards of *six millions of dollars.* To work the telegraph lines, it takes annually 720 tons zinc, worth $60,-000; more than 1,000,000 pounds nitric acid, worth $120,000; and $30,000 worth of mercury; besides a considerable amount of sulphuric acid, etc.; *none of which are used by the magneto-electric machines for generating electricity* (a uniform and steady current being produced by Mr. Baker's last improved arrangement), *thereby giving them immense advantages over the galvanic batteries both in economy and time.*

INCREASED EFFICACY OF LIGHTNING-CONDUCTORS.

M. Perrot has submitted to the French Academy of Sciences some interesting observations on the above subject. The metallic roof of a building, he says, whether communicating with the lightning-conductor or not, does not preserve the metallic plates below it from the electric influence of the storm-cloud. Each of these plates, if it be in connection with the conductor which receives the shock, sends off sparks to the neighboring conducting bodies. If, then, we wish to avoid accidents similar to one which recently happened to a military storehouse furnished with seven conductors, it is indispensable that each conductor should be placed where it will be perfectly sheltered from any electric shock, a position which M. Perrot says that he has obtained by a very simple arrangement exemplified in the following experiments: — At an explosive distance from a disc representing a cloud, and in connection with the electric-machine, he places a metallic wire connected with the earth, and representing the lightning-conductor to be attacked. Parallel to this disc, and at a little distance from it, are disposed several metallic leaves or gratings, separated several centimetres from each other. These, designed to represent the roof and the metallic plates beneath it, may be connected with each other or with the conductor. Now, when these leaves are insulated from the struck conductor, the spark and the commotion felt by the hand touching these leaves are not felt very sensibly; but if one of these leaves be put in connection with the conductor it will (to the exclusion of all the others) give rise to a powerful spark and commotion. The same will occur with each leaf, and with the whole, if connected with the conductor, each time that it is struck. M. Dumas, who was present, said that M. Perrot had put his hand on a problem of the very highest importance, and would no doubt give a complete solution of it, to the great satisfaction of philosophers, architects, and naval officers.

WELDING IRON IN VACUO.

In a communication to the Academy of Sciences, at Paris, M. Faye has given the following account of some experiments in which M. Ruhmkorff took part. An iron wire was cut in two, and the ends brought into contact without any mechanical pressure: this done, by means of an electrical current the wires were heated to a dark red *in vacuo*, and they were thus instantaneously welded together. The wires were at an angle of one hundred and fifty degrees; and yet, with that inclination, they supported a weight of upwards of three kilogrammes before breaking at the point where the welding had been effected. The same experiment, made in the open air, by way of a counter-proof, led to no result. Encouraged by this success, M. Faye heated a thick iron cylinder *in vacuo*, — it had been sawed in two, and the parts then joined together by two screws. The latter having inadvertently been made of brass, they began to melt during the heating process; but although but a very small portion of the metal had actually become fluid, it penetrated by capillary attraction, aided by the vacuum, into the smallest fissures, soldering the two pieces with extraordinary nicety.

GALVANIZING IRON.

It has been recently shown that the process of zincing iron, or, as it is generally called, "galvanizing," which has been the subject of more than one recent patent, and, of course, of much litigation, was practised in France about the year 1740 precisely as it is done at this day; and a description of the process was given by Bishop Watson in his well-known and widely-circulated *Chemical Essays*, published towards the end of the last century.

NEW CHRONOGRAPH.

M. Lissajous has presented to the French Academy a plan of a new instrument for measuring small intervals of time, by which he proposes to estimate accurately the five-hundred-thousandth part of a second. The instrument is to be composed of, first, a silvered drum about forty inches in circumference, which is to be coated with lamp-black for the experiment; it makes three turns per second. Second, a tuning-fork giving five hundred vibrations per second, with the electric apparatus for preserving its vibrations according to the plan of M. Lissajous; a point fixed upon this marks on the drum during the experiment. Third, an electrical apparatus to give a spark at the beginning and end of each phenomenon. That which characterizes the new apparatus is the length of the line on the drum, which corresponds to the very short duration of the phenomenon, and the facility of dividing it by the microscope. — *Kosmos.*

THE PRODUCTION OF SOUNDS AND VISIBLE VIBRATIONS BY VOLTAIC CURRENTS.

Mr. George Gore, the celebrated English physicist, has furnished to the Royal Society the following particulars respecting the production of vibrations and sounds by voltaic electricity. He says: —

If a large quantity of electricity is made to pass through a suitable good conducting electrolyte into a small surface of pure mercury, and especially if the mercurial surface is in the form of a narrow strip about one-eighth of an inch wide, strong vibrations occur; and symmetrical crispations of singular beauty, accompanied by definite sounds, are produced at the mutual surfaces of the liquid metal and electrolyte.

In my experiments the crispations and sounds were readily produced by taking a circular pool of mercury from one to three inches in diameter, surrounded by a ring of mercury about one-eighth or one-sixteenth of an inch wide, both being contained in a circular vessel of glass or gutta-percha, covering the liquid metal to a depth of about half an inch with a rather strong aqueous solution of cyanide of potassium, connecting the pool of mercury by a platinum wire with the positive pole of a battery capable of forcing a rather large quantity of electricity through the liquid, and connecting the ring of mercury with the negative platinum wire. The ring of mercury immediately became covered with crispations or elevated sharp ridges, about one-sixteenth of an inch asunder, all radiating towards the centre of the vessel, and a definite or musical sound was produced, capable of being heard, on some occasions, at a distance of about forty or fifty feet. The vibrations and sounds ceased after a short time, but were always reproduced by reversing the direction of the electric current for a short time, and then restoring it to its original direction. The loudness of the sound depends greatly upon the power of the battery; if the battery was too strong the sounds did not occur. The inference drawn by Mr. Gore from these experiments is, that voltaic electricity, like heat and light, may be viewed as consisting of vibrations, which are ordinarily inappreciable, but which, under certain conditions, such as these described, may be gradually increased so as to become visible. These results are evidently worthy of the most attentive examination; their value as tending to elucidate the nature of voltaic electricity can hardly be overrated, although it is evident that a sufficient number of facts are not yet accumulated to prove the inference that has been deduced.

THE ELECTRIC ORGAN IN FISHES.

The hypothesis propounded by Sir John Herschel, and eagerly adopted by many physiologists, that the brain is a voltaic battery of which the nerves are the conductors, was retained as a convenient simile, after the identity of nerve force and electricity had been generally discredited; and the nerves were then spoken of as *conductors* of the force *generated* in the nerve-centres. Even as a simile, however, this became inadmissible when it was proved that the nerves were in no sense *conductors*, but possessed their own special force, — neurility, — which could operate in complete independence of any centre, and which was to the nerves what contractility was to the muscles, and sensibility to nerve-centres. The hypothesis of the battery, and the hypothesis of nerve-force being electricity, seemed confirmed by the electrical phenomena exhibited in certain fishes, which have justly excited considerable attention from men of science. The fact that the electric organ is connected with the brain by an enormous mass of nerves, and the fact that the discharge is under the control of the animal's will, together with the fact that destruction of the brain on one side destroyed the electrical power on that side, — an effect also produced by merely dividing the nerves, so as to cut off the communication with the brain, — seemed to establish the hypothesis of the brain's being the central battery.

This has now been thoroughly disproved. M. Charles Robin long ago suggested that the electric organ, and not the brain, was the source of the electricity discharged. He declared that the tissue of this organ has the special property of producing electricity, just as the muscular tissue has the special property of contractility; and the influence of the nerve force is similar in both cases, — exciting the activity of the electric tissue as it excites the activity of the muscular tissue. Against this it was maintained that the brain generated the electricity, which passed along the nerves to the electric organ, and was there condensed and held in reserve. In a memoir recently presented to the Academy of Sciences, M. Moreau brings forward facts which conclusively settle *this* point. Having divided all the nerves which supplied the electric organ on one side of the fish, thus entirely removing all communication between the brain and the organ, he excited the cut ends of these nerves, and produced electric discharges. This is precisely analogous to the experiment of producing contraction in a muscle removed from all connection with the brain (or indeed in an amputated limb), by exciting its nerve. If the experiment stopped there it would prove nothing. We might say that the electric organ had a certain amount of electricity condensed in it, and this was discharged when the nerves were irritated; such has been the objection raised in the case of the stimulated muscle. But in neither case does the experiment stop there. Electric fishes, it is notorious, exhaust their electric power after a few shocks, and some repose is necessary before their organ recovers its power. When, therefore, the discharges had ceased, M. Moreau returned his mutilated fish to the water; allowed it a certain time for repose; removed it from the water, and on again irritating the cut ends of the nerves, again produced powerful and reiterated discharges; and these discharges were not appreciably less intense than those produced from the uninjured side! "These experiments," says the report of the commission, "conduct to the rigorous conclusion that the brain is only an excitor, a point where the nerves receive a stimulus. The electric organ is related to the brain as the muscles are related to the brain." Precisely analogous is the case with the muscle when separated from its nerve-centre; repeated irritations of the nerve exhaust its neurility so that it will no longer cause the muscle to contract; but after a period of repose, under proper conditions, the nerve will again, on being stimulated, cause the muscle to contract. And that this is owing to the nerve's having recovered its neurility, may be proved by this: at a time when a stimulus applied to the *nerve* causes no contraction in the muscle, certain stimuli applied *directly to the muscle* cause it to contract. Nay, more, at a time when a stimulus applied to a point of a nerve at the distance of one inch from the muscle produces no contraction, this stimulus applied to a point at only half an inch is followed by contraction.

M. Moreau's observations are thus not only valuable as regards the source of the electricity in fishes, and the part played by the brain in the electrical phenomena, but also as confirming the existence of a special force (neurility) in the nerves themselves, a force developed out of the molecular changes of the nerve tissue, and not derived from the brain. The nerves are agents, not passive conductors. That nerves are not simply conductors, but are endowed with a special force of their own, is strikingly seen in Pflüger's empirical law, which is thus stated: "One and the same irritant which is applied successively to two different points of a nerve does not irritate the muscle in the same degree, but the irritation which is applied at the greater distance from the muscle acts the more powerfully." Pflüger thinks that "the excitation increases in an avalanche-like manner, and this is the more considerable the greater the portion of nerve over which it travels."

CURIOUS PHYSIOLOGICAL PHENOMENA.

M. Louis Luca, a Parisian scientist, lately received a select circle of visitors at his house, to exhibit and explain the principle of an apparatus of his own invention, by which a physiological fact of great importance is rendered apparent, viz., the direct action of the living frame on the magnetic needle. The apparatus itself is of extraordinary simplicity. A single element of Bunsen's battery has its poles in communication with an electro-magnetic bobbin, surmounted by a graduated disc, bearing a magnetic needle which oscillates freely round its centre, as in the common compass. This part of the apparatus is protected by a glass shade; the plate may be raised and lowered at pleasure by a wheel and rack. The conducting wires, after communicating with the bobbin, branch out towards the operator, and are connected together by a loose metal chain. The apparatus being in this state, the needle remains perfectly quiescent, until the operator takes hold of the chain either with one hand or both, when the needle at once begins to move, describing arcs of from ten to ninety degrees. No principle hitherto admitted into physical science can account for this strange phenomenon, and we are compelled to admit a physiological action capable of producing such motion. The experiment was varied in many ways in our presence, and we were ourselves allowed to test our individual power on the needle. That the cause of the motion was of a physiological nature, was further proved by the circumstance that the oscillations of the needle varied in intensity according to the persons experimenting, and even according as the same person might be differently affected either by tranquillity or a warm discussion, such different states naturally modifying the susceptibility of the nervous system. Stranger still, some persons present produced the oscillations by merely touching the chain with a glass rod about two metres in length, glass being, as our readers know, a non-conductor. Whatever explanation may hereafter be given of M. Luca's discovery, one fact seems even now indisputable, namely, that the human body may directly influence the needle; what consequences may be evolved therefrom, time alone can show. — *Galignani.*

DE LA RIVE ON THE AURORA BOREALIS.

M. de la Rive conceives that two general facts relating to the aurora are established: "1st, the coincidence between the appearance of the Boreal and the Austral auroras; 2d, that auroras are atmospheric phenomena which take place within the limits of the atmosphere, but not beyond it." He seeks to show that the positive electricity carried to high regions of the atmosphere by vapors from tropical seas, and which the trade-winds accumulate near the polar regions, acts by induction on the negative electricity with which the earth is charged. There results, he says, "a condensation of contrary electricities in those portions of the earth and of the atmosphere which are nearest each other, and in consequence a neutralization in the neighborhood of the poles, which takes place under the form of more or less frequent discharges as soon as their tension has reached a limit which cannot be maintained. These discharges ought to take place simultaneously at both poles, since, as the conducting power of the earth is perfect, its electrical tenison ought to be sensibly the same, with some slight differences arising solely from accidental variations in the stratum of air interposed between the two electricities. There are thus upon the earth during the appearance of the auroras two currents proceeding from the poles to the equator; but if the discharge only takes place at one pole — the southern, for example — there is no longer in the northern hemisphere a current directed from north to south, but a weaker current directed from south to north. This change gives an eastern declination to the compass-needle instead of the western declination which occurs when the boreal discharge takes place, and the current is directed from north to south.

"It is known that auroras are accompanied by more or less intense currents in telegraphic wires. Mr. Walker, in England, and Mr. Loomis, of America, have made them the subjects of special study, and they have found that they vary constantly not only in intensity, but likewise in direction, coming alternately from north to south, and from south to north. If we remember that the currents propagated by telegraphic wires are derivative currents gathered by means of large metallic plates sunk in the moist soil, it will appear that these plates are not slow to polarize themselves under the chemical action of the current which they transmit, and that they ought to determine in the wire which unites them an inverse current as soon as that which occasioned their polarization ceases or diminishes its force; and all observers know that the auroras exhibit a very variable and perpetually oscillating light.

"The change which occurs in one terrestrial current when the discharge passes from one pole to another — from the north to the south, for example — determines also a change in the direction of the currents of the telegraphic wires, which in that case flow from south to north, instead of from north to south; but the new current is much weaker than the old one, except when it unites with the secondary currents arising from the plates.

"There is, however, a great difference in the results obtained when, instead of observing the currents collected by telegraphic wires, we study the perturbations of the magnetic needle which accompany auroral manifestations, as in the latter case there are neither electrodes nor secondary currents, but only one direct action of the principal current. This current may vary in intensity, but it must always operate in the same way (*même sens*), while the discharge takes place at the same pole, whether it be strong or weak, and it will not change its character until the discharge nearly ceases at the nearest pole, in order to operate almost exclusively at the other; whilst by reason of the effect of secondary polarities a change in intensity suffices to produce a change of direction in the currents of telegraphic wires. This difference is strikingly shown by comparing the graphic representations of perturbations in the magnetic needle observed by Mr. Stewart at Kew, during the auroras of the 2d September, 1859, with the results of Mr. Walker's observations of the currents exhibited by telegraph wires at the same time. I have succeeded in experimentally verifying these observations by transmitting the discharge of a Ruhmkorff's coil through rarefied air, placing in the circuit some water holding a little salt in solution, and in which two plates of metal were immersed. As soon as the principal current was weakened or stopped the inverse current was exhibited by the plates.

"In order to reproduce all the details of the natural phenomena, I caused an apparatus to be constructed composed of a sphere of wood about ten inches in diameter, which represented the earth, and carried at each pole a bar of soft iron about two inches long and about one inch in diameter. Each bar rested on a vertical cylinder of soft iron to which it was united, and thus the sphere was supported. So arranged, the sphere had a horizontal axis terminating in two appendages of soft iron which could be magnetized by bringing the two cylinders on which they rested in contact with the poles of an electro-magnet, or by surrounding the cylinders with coils of wire traversed by electric currents. Each of the iron bars was surrounded by a glass cylinder (*manchon*) between five and six inches in diameter, and about seven inches long, and in which it occupied an axial position, projecting into the middle of the glass. The two vessels were hermetically sealed by two metallic caps, one of which was traversed by the iron bar, while the other carried a metal ring upon two arms, the centre of the ring coinciding with the end of the iron bar, and having its plane perpendicular to the axis of one bar. The diameter of the ring is a little less than that of the glass. Stopcocks were conveniently placed to allow of a vacuum being formed in the glass vessels, and any kind of gas introduced.

"To use this apparatus, the wooden ball is covered with two strong bands of bibulous paper, one occupying its equator and the other crossing it from pole to pole, and making contact with the two bars of iron. On this last band, pieces of copper about one or two thirds of an inch square are fixed at equal intervals with copper tacks that penetrate the wood. All the copper squares are arranged in the same meridian. Between two of the squares a metallic communication is established with the thread of a galvanometer placed about twelve yards off, so that its needle shall not be directly influenced by the electro-magnet. Having thus arranged the apparatus, the paper bands are moistened with salt and water, and the equatorial band is connected with the negative electrode of a Ruhmkorff's coil, which has its positive electrode brought into communication, by means of a bifurcated wire, with the two metallic rings which are inside the glass vessels, and in highly rarefied air. The discharge is soon seen as a luminous jet between the rings and the extremity of the iron bar, sometimes in one vessel, sometimes in the other, but rarely in both at once, although both are placed under apparently the same circumstances.

"As soon as the soft iron is magnetized, the jet spreads and forms an arc round the central wire, animated by a rotary movement, the direction of which depends on the character of the magnetization. It is evident that it depends also on the direction of the discharge, but we have supposed this direction constant, and resembling that of nature, that is to say, directed from the circumference towards the centre. It is important to notice that if the air be not too rarefied, a moment is observed in which, when the iron bars are magnetized, the rotation begins, and the jet not only expands into an arc, but darts brilliant rays that remain quite distinct from each other, and turn round with greater or less velocity like the spokes of a wheel. In this we see an exact representation of what occurs in the aurora borealis, when the luminous arcs, being all impressed with a movement of rotation from west to east, dart luminous jets in the higher regions of the atmosphere. These jets do not occur unless the iron is magnetized, and they may be stopped if the air is highly rarefied by introducing a vaporizable liquid, such as a drop of water. It is impossible to produce them if the discharge, instead of being directed, as in nature, from the circumference to the centre, passes in an opposite direction."

M. de la Rive adds, that on examining the galvanometer with which the two wires previously mentioned are in communication, a secondary current will be indicated, its character and direction being determined by whether the discharge takes place at one pole or the other; and he states that he can imitate the disturbances which the magnetic needle experiences when the auroras occur. — *Comptes Rendus.*

SECCHI ON MAGNETIC AND ATMOSPHERIC PERTURBATIONS.

In a recent letter to the French Academy, the distinguished Roman astronomer gives a summary of the conclusions he has arrived at respecting the connection between magnetic perturbations and atmospheric movements. This he considers established, first, by the great variations of magnetic elements, and especially in the intensity of the horizontal force, on the occurrence of storms; secondly, by the irregularities which accompany periods of squalls; thirdly, by the variations in delicate magnetic instruments which immediately precede or follow great changes in the weather; fourthly, by variations of intensity corresponding with variations of the winds; fifthly, by the *aurora borealis*, which, considered as a signal of variation in wind and weather, belongs to the class of phenomena under discussion.

The immediate cause of the connection thus traced M. Secchi ascribes to atmospheric electricity, which, when discharged from the air to the earth, must generate strong currents by which the needle is affected. Such currents, he observes, exist not only during auroral manifestations, but also during storms, and are exhibited by each instrument according to its nature, the galvanometer showing changes in tension, and the compass-needle making known alterations in the total force of the current which passes beneath it. With reference to the questions of whence comes the electricity circulating in the soil, and what is its immediate vehicle, he replies by pointing to the precipitations from the atmosphere. The rain especially, he says, discharges an immense quantity of electricity into the earth, and, in general, it may be said that strong actions upon the instruments only occur after a rainfall has taken place at some point more or less remote, even beyond the limits of the visible horizon. This circumstance may, perhaps, explain the fact that magnetic perturbations indicate approaching squalls. Rain usually produces negative electricity over a considerable extent of atmosphere, and it is itself generally negative, which accounts for the notable diminution of horizontal intensity which precedes squalls. The precipitation of vapor without rain, which often happens between eight and nine on clear nights, and which is accompanied by very strong electricity, may explain the magnetic perturbations which occur at that time, and the diurnal electric period which corresponds with the movements of the horizontal needle may belong to the same class of meteorological facts. Even the *aurora borealis* may be included in this category, as there is a continual fall of ice-needles, almost invisible, but whose existence is clearly shown in the narratives of Polar voyages. Atmospheric electricity on these occasions may, perhaps, be exalted by accessory causes, such as the change which takes place when vapor passes to the state of ice, or by the friction of wind against the little icicles in a dry and very insulating atmosphere, and also by the inductive action of superior regions on the falling and floating particles of ice. These various subjects, M. Secchi tells us, are illustrated in his *Memoires*, but he does not pretend that magnetic disturbances have no other causes than those indicated in the preceding remarks.

CONNECTION BETWEEN EARTHQUAKES AND MAGNETIC PERTURBATIONS.

M. Lamont, director of the Astronomical Observatory at Munich, states that on the morning of December 26, 1861, while rectifying the position of his magnetic apparatus, he remarked in all the instruments an unusual perturbation. Their position changed rapidly and irregularly,—sometimes one way, sometimes another; and at the same time there occurred a vertical vibration in the needles. A few days after he learnt that at the very time he was making these observations an earthquake, which occasioned much damage, took place in Greece. This, he says, proves once more, not only that the convulsions produced by earthquakes are perceived at a great distance, but also that the forces which produce them modify terrestrial magnetism to a certain extent.

MAGNETISM OF HOT AND COLD ROLLED IRON.

Prof. Airy, in a communication to the Royal Society on the above subject, states, first, that he had been desirous of examining whether differences in the degree of change of subpermanent magnetism, such as are exhibited by different iron ships, might not depend on the temperature at which the iron is rolled in the last process of its manufacture; and for the purpose of experimenting, he had received from the Dudley Iron Works twenty-four plates of iron, each sixteen inches long, four inches broad, and one-fourth inch thick; twelve of which, after having been manufactured with the others in the usual way, had been passed through rollers when quite cold. Each set of twelve was divided into parcels of six each, one parcel being cut with the length of the bars in the length of extension of the fibres of the iron, the other being cut with the length of the bars transverse to the length of extension.

For experimenting on these, a large wooden frame was prepared capable of receiving the twenty-four bars at once, either on a plane transverse to the direction of dip at Greenwich, or on a plane including the direction of dip. In some experiments, these planes were covered with flag stones, and the bars were laid upon the flag stones; in others, the bars were laid immediately upon the wood. While there lying, they were struck with iron or wooden hammers of different sizes. The bars of the different classes were systematically intermingled, in such a way that no tendency of the arms to give blows of a different force or kind in special parts of the series could produce a class error in the result. For examination of the amount of polar magnetism in each bar, it was placed at a definite distance (five inches) below a prismatic compass, which was used to observe the apparent azimuth of a fixed mark; the bar was then reversed in length, and the observation was repeated in that state.

The number of experiments was twenty-one. They were varied by difference in the succession of positions of the bars, difference of time allowed for rest, difference in the violence of the blows, etc. The principal results appear to be the following:—

1. The greatest amount of magnetism which a bar can receive appears to be such as will produce (on the average of bars) a compass deviation of about eleven degrees, the bar being five inches below the compass. It was indifferent whether the bars rested on the stone or on wood, or whether they were struck with iron or with wood, the bars lying on the dip plane while struck.

2. When the bars, thus charged, lay on the plane transverse to the dip, they lost about one-fifth of their magnetism in one or two days, and lost very little afterwards.

3. When the charge of magnetism is smaller than the maximum, the diminution in a day or two is nearly in the same proportion as for the maximum.

4. The effect of violence on the bars, when lying on the plane transverse to the dip, is not in all cases to destroy the magnetism completely; sometimes it increases the magnetism.

5. The cold-rolled iron receives (under similar violence) or parts with (under similar violence) a greater amount of magnetism than the hot-rolled iron, in the proportion of six to five.

6. There is some reason to think that the hot-rolled iron has a greater tendency to retain its primitive magnetism than the cold-rolled iron has.

7. There is some reason to think that, when lying tranquil, the hot-rolled iron loses a larger proportion of its magnetism than the cold-rolled iron loses in the same time.

DEVIATION OF THE COMPASS AND THE MAGNETISM OF IRON SHIPS.

At the meeting of the British Association, 1862, Mr. F. J. Evans, on behalf of himself and others, read a report "On the Three Reports of the Liverpool Compass Committee, and other recent Publications on the same subject,"—undertaken at the request of the British Association. The papers included were, severally, by the Astronomer Royal, the late Dr. Scoresby, and Capt. Johnson, R. N., on the deviation of the compass and the magnetism of iron ships; as also contributions in the same field of inquiry by the reporters. After a general review of the formulæ employed and recommended, the Report states that the first and most important general result which is derived from all the observations recorded in these works, and from many more which have not been published, is, that the observed deviations of the compass are represented by the formulæ derived from Poisson's theory with a correctness which is within the limits of error of observation. It was also stated that the following conclusions might be accepted as established:—

1. That the magnetism of iron ships is distributed according to precise and well-determined laws. 2. That a definite magnetic character is impressed on every iron ship while in the building slip, which is never afterwards entirely lost. 3. That a considerable reduction takes place in the magnetism of an iron ship on first changing her position after launching, but afterwards that any permanent change in its direction or amount is a slow and gradual process. 4. That the original magnetism of an iron ship is constantly subject to small fluctuations, from change of position, arising from new magnetic inductions. 5. That the compass errors occasioned by the more permanent part of a ship's magnetism may be successfully compensated; and that this compensation equalizes the directive power of the compass-needle on the several courses on which a ship may be placed. On the effect of heeling, a considerable body of evidence is collected; the most important practical result, as to the amount of the heeling error, is the great amount to which it reaches in certain ships and in certain positions in the ship, several examples of even two degrees of change for one degree of heel being recorded. The Report points to certain desiderata:—1. That in the construction of iron vessels regard should be had to the providing a proper place for the compass, the present difficulty being to reconcile this with the requirements of construction and of working the vessel. 2. That for throwing light on the points which are still obscure, the complete magnetic history of some iron vessels in various latitudes should be known: this might be accomplished by observations of durations, and horizontal and vertical force, made at various fixed positions, in some new iron vessel, in an extended voyage in both hemispheres, and in which the magnetical observations would be made an object of importance.

In a lecture on the above subject by Mr. J. T. Towson, Secretary of the Liverpool Marine Board, Mr. T. stated that in treating of the deviation of the compass in an iron ship, they must consider that it was affected by magnetism permanent or sub-permanent and inductive: the one was a magnet in all positions; the other was a magnet only when in a certain position with regard to another magnet. The permanent was the most considerable of the disturbing forces, and it was an extraordinary fact that a great deal of the disturbing force depended on the direction in which the head of the ship was placed at the time of her building. The steamer *Great Britain* had been knocked about in Dundrum Bay for a whole winter; she had been in both hemispheres; she had been repaired in a dock with her head in a contrary direction to that in which it was at the time of her building; still it was easy to ascertain on examination which way her head pointed at the time she was being built. This was an instance of a vessel retaining her magnetism, notwithstanding the causes he had mentioned likely to change or disturb it. When the head of an iron vessel was at right angles with the slip on which she was built, then the compasses would be affected by the permanent magnetism; when her head was turned toward her building slip at an angle of 45°, then her compasses were affected by the inductive magnetism. A vessel in heeling over port or starboard would be most likely affected when standing north and south, and a ship proceeding from one hemisphere to the other would be most affected when standing east and west. The lecturer then entered into a series of elaborate illustrations, showing the calculations which should be made in dealing with a subject which was surrounded by so much difficulty. Thus far their investigations had but showed them how little reliance could be placed on the compass at all. It required constant watching, and they might always suspect that it was affected by the magnetism of the iron of which the vessel was constructed. One result of the introduction of iron in shipbuilding operations must be the employment of masters and mates of superior education.

BONELLI'S ELECTRIC TELEGRAPH.

For many years the attention of telegraphists and the hopes of the public have been directed to the possibility of automatically reproducing an original dispatch; but difficulties, apparently insuperable, have militated against all realizations of the project. The electric telegraph, recently devised by Signor Bonelli, the inventor of the electric loom (see *Annual of Scientific Discovery*, 1861, p. 113), is, however, an immense stride towards the attainment of this end, even if it be not perfection itself. We will endeavor to describe the principle of the new system, as exhibited in the Great International Exhibition of 1862.

Let the reader suppose himself to be the operator; before him he will find an oak table, six or seven feet in length, seventeen to eighteen inches wide; along the centre of this table runs a miniature railway, terminated at either end by a spring buffer, and spanned midway by a kind of bridge six inches in height and two and a half or three inches wide. Upon this railway is placed a species of wagon, one yard long and five inches wide, three and a half in height, running upon four brass wheels; on the surface of this wagon are two long rectilinear openings—the one occupying the upper half and destined to carry the message which is to be sent, the other occupying the lower half, and intended for the message which may be to be received; upon the bridge are two small metal combs, each containing a number of insulated teeth, answering in number to, and connected with, the insulated conductors of which the line is formed. The combs differ from one another; the one which is to dispatch the message, being formed of so many teeth having a certain freedom of action, is on the side of the bridge farthest from the operator; the other, or writing comb, is formed of a similar number of teeth fixed in a block of ivory, and forms a perfect line, which rests with a slight but regular pressure transversely on the paper, and occupies the nearer portion of the said bridge. We will suppose that the tables have been tested, and that a number of messages have been sent for dispatch; these messages are distributed to a given number of compositors, who set them up in ordinary type with great rapidity; the first that is finished is handed to the operator, whose wagon has already been pushed to the upper end of the rail and is held there by a simple catch; he places this dispatch in the opening destined for it, and in the second opening he places a plate of metal upon which have been laid four, five, or six strips of paper prepared with a solution of nitrate of manganese; this done, he turns a small handle, and watches if the operator at the other end has done his work; the wagon is at once freed from the catch, and is set in motion by a simple weight, the pace being regulated by a fan; the type of which we have spoken is thus brought under the action of the dispatching comb, and runs lightly under its teeth from end to end; one-half of the journey being made, the writing comb comes in contact with the prepared paper. If the operator at the other end has had a message to send, it will have been printed in clear, legible characters, of a deep brown color, answering, with unerring fidelity, to the forms over which the corresponding type comb has passed, while the operator (the reader) learns that *his* message has as surely been received; the message is stripped off, the wagon remounted, the type-box changed, and the process of transmission and reception repeated. All this, which takes so long to describe, is so rapidly accomplished that from *four hundred and fifty to five hundred messages may be dispatched per hour*, the passage of the wagon occupying ten to twelve *seconds*, during which time a message has been sent and received at each end of the line. It will be seen at once that it is morally impossible that any demand should arise that would *over-tax* the transmitting powers of this system, the whole question resolving itself into *rapidity of supply*. Now, ordinary compositors can set up a message of thirty words in one and a half minutes; this period is, of course, divisible by the number of compositors, ten giving ten messages each minute and a half, twenty giving twenty messages, and so on. By this happy application of electric science to the typographic art, it is believed that the price of dispatches will be reduced to a minimum, and the rapidity of distribution vastly increased, while the chances of mistake are almost annihilated, being reduced to the possibility of *typographic error*, in the first and only process in which error appears to be possible. It is scarcely needful to say that the dispatch received is actually sent out; as the wagon descends it is stripped from the plate, passed for a few seconds under a stream of water, blotted off, dried by hot rollers, and put into the envelope, which is by this time ready to receive it.

When it is remembered that no existing system is capable of dispatching with a pair of machines more than an average of twenty-five messages per hour, and that these are transmitted and received in conventional signs, it will be evident that a great step has been taken, and the public cannot but be interested in what promises to produce so great a revolution in the science of telegraphy.

It is clear that the application of this system to *autographic* telegraphy is a simple question of time. What seven, or eight, or eleven wires passing by the agency of combs over the surface of type can accomplish, a greater number passing over manuscript can equally perform; the same message being of course written either on metallic paper with an insulating ink, or *vice versa;* indeed it would be difficult to assign the limits of its application. The fact that the principle upon which the system is based has been tried upon a line exceeding three hundred miles, renders its practicability for long distances no longer doubtful; and a line between Liverpool and Manchester, England, is, in fact, now constructing for public service.

Caselli's Copying Telegraph. — The peculiarity of this telegraph consists in a pendulum suspended to an endless screw; a small steel hand being attached to its lower end, at right angles with it. Beneath it, parallel to it, and at right angles with the steel hand, is placed a metal plate, upon which the dispatch to be transmitted is written in ordinary ink. At the point of destination is a similar pendulum, suspended in the same way, and with a similar little steel hand attached in like manner to its lower end. Under this second pendulum, parallel to it, and at right angles with its little hand, is placed a sheet of prepared paper, upon which the transmitted dispatch is to be received. When the telegraph is put into operation, the two pendulums vibrate simultaneously backwards and forwards across the surface of their respective sheets, descending a hair's breadth lower at each vibration. Whenever, in its passage to and fro across the surface of the metal plate, the steel hand of the first pendulum comes into contact with the ink (which is a non-conductor), the electric current is transmitted to the second pendulum, and produces, through the steel attached to this second pendulum, a chemical action, which causes a stain upon the prepared paper in contact with it at each point of its surface touched by this second hand during the transmission of the electric current. The form of the letters, or other lines, traced in ink upon the surface of the metal plate at one end of the line, is thus reproduced, in successive rows of minute, dot-like stains, superposed one upon the other so closely as to show like a single stroke (unless examined with a microscope) upon the sheet of paper at the other end of the line. This mode of electric telegraphing has been already attempted in England and France; but the dispatches received were always so much blurred as to be scarcely legible, and the invention was, therefore, practically worthless. Professor Caselli has succeeded in causing an instantaneous suspension of the transmission of the electric current whenever the first pendulum is passing over those portions of the metal plate which are free from ink; so that the chemical action of the second hand, in its oscillations across the surface of the paper, takes place only at those points which are touched by it during the moments when the electric current is being transmitted. The blackened points of the sheet of paper consequently correspond exactly to the points of the metal plate that are covered by the ink; and thus present a fac-simile of the writing, portrait, plan, pattern, etc., of the original dispatch, which, by this most admirable development of the electro-telegraphic art, is reproduced with perfect clearness and exact fidelity upon the paper at the further end of the telegraphic line. The cost of establishing such a telegraph is, at present, rather greater than for the Morse and other telegraphs in ordinary use; but the machinery, when once established, is easily managed.

THE ATLANTIC TELEGRAPH.

Two schemes are now before the public for reviving this important enterprise: the one for a continuous cable from Ireland to Newfoundland, the other for a line in four sections, the points of intermission being the Faroe Islands, Iceland, Greenland, and Labrador. The promoters of each of these enterprises appear most confident, not only of the perfect feasibility of their own plan, but also of the existence of fatal defects in that which is propounded by their rivals. On behalf of the sectional undertaking, for example, it is urged that the difficulty of working through long circuits, owing to the retarding influence of inductive electricity, increases in about the square of the length of the line when long insulated wires are laid down either in the earth or under water. If this were absolutely true the delay arising from reading off and re-transmitting messages at four stations would still have to be weighed against that springing from the cause assigned. But it appears by no means certain that the theory thus broadly laid down is to be unhesitatingly accepted as the embodiment of an unvarying law. The most competent electricians aver, that the operation of the law referred to is susceptible of considerable modification from surrounding circumstances. It has been found, that whereas the induction increases only as the circumference of the copper wire, its conducting power increases as the square of its diameter; and hence it is inferred that if a wire of considerable size be coated with insulating material to such a thickness as shall give the same induction as to a smaller wire, an enormous augmentation of speed will be attained. Taking these conclusions as a basis of calculation, it is estimated that such a cable as that which is now being manufactured to connect Ireland with Newfoundland, containing 510 pounds of copper and 550 pounds of gutta-percha to the mile, will transmit from eight to twelve words per minute. If this be so, such rapidity is as great as we can reasonably hope to attain.

On the other hand, it is alleged that if two lines of the same dimensions and cost as regards copper and insulation were laid,— one for 500 miles and the other for 1,500,— the former could be worked through for messages at nearly nine times the speed of the latter. According to this theory, the sectional cable to Labrador, by way of Iceland and Greenland, would transmit 108 words per minute; but this is obviously incredible, since it is known that the English land lines are seldom worked at a higher speed than 22 words per minute.

There are some arguments urged with regard to the rival lines upon which every one gifted with common sense is competent to form a judgment. Every one can understand that on the Labrador line great additional expense must be entailed by the necessity of keeping at each intermediate station a staff of clerks to read off the messages and retransmit them along the next section. It needs no profound scientific training to comprehend that the inaccessibility of the coasts of Iceland and Greenland, save during six weeks of the year, must throw great difficulties in the way of repairing some portions of the cable if they should chance to get out of working order.

An average store of worldly experience and geographical acquirement will enable any one to realize the difficulty of keeping in good condition a land line of one hundred and fifty miles in length across Iceland, and the peril surrounding that portion of the cable which passes over stormy Labrador. On these points we can judge for ourselves, without seeking the assistance of scientific men. But then, on the other hand, these drawbacks would lose much of their importance if it proved to be really true that the line from Ireland to Newfoundland would labor under radical electrical disadvantages from which its rival would be free. This is the point upon which we desire reliable information before we can decide which of the two schemes is most worthy of public patronage, and we can obtain it only from a competent scientific commission of inquiry. As the case at present stands, the preponderance of reliable testimony appears to be decidedly against the theory that for the transmission of messages the Labrador line would possess greater rapidity or certainty than its less expensive and less complicated competitor. — *London Star.*

Capt. Haskin, R. N., who has recently been engaged in examining the Atlantic off the west of Ireland, on behalf the Transatlantic Telegraph Company, has recently made a report, from which we derive the following: — "I think there can be no reasonable doubt now but that the descent from the Irish bank to the bed of the ocean is all that we can desire for the safe laying of the cable. So far from its being a precipice, a locomotive might run up some of the inclines, and many turnpike roa ls have steeper ascents. The face of this slope — and, indeed, the bed of the ocean everywhere when below the depth of five hundred or six hundred fathoms — is covered with the soft, clayey substance called by seamen 'ouze.' The deposit, in the opinion of Prof. King and other naturalists, is going on so copiously and unceasingly, that a cable once laid would, in the course of a few years, be 'covered up,' and so forever sealed against the action of all external agencies."

NEW PHENOMENA OF CRYSTALLIZATION.

Some remarkable phenomena of crystallization have been noticed by Mr. Petschler in the preparation of glass plates with bichromate of potash and gelatine, for photographic purposes. The striking peculiarity is, that the inorganic salt in contact with the organic matter produces vegetable forms; specimens on glass plates representing mosses, ferns, and algæ in beautiful ramifications, which vary in many ways, dependent upon the strength of the solution, temperature, state of the atmosphere, and other causes. The plates were prepared in different ways. Some were first coated with collodion, on the surface of which a hot mixture of gelatine and bichromate of potash was poured, and then allowed to cool and dry spontaneously. In a few hours the crystals began to form and ramify themselves over the plate. The gelatine mixture was composed of three parts of gelatine and water, twenty grains to the ounce, to one part of a saturated solution of bichromate of potash. Several other plates were prepared in which the order of application of the ingredients was varied, or some of them omitted, all of which gave beautiful, tree-like crystalline forms. The great variety and beauty of these vegetations must be seen to be appreciated, as they can with difficulty be represented by drawings. Mr. Petschler believes that no chemical combination takes place between the salt and the gelatine, but that the latter acts simply as a medium. The gelatine, when firm, retains a certain quantity of water; but when the moisture is driven off by heat, the crystallization is suspended. There is great similarity in appearance, and there is, possibly, some connection in cause between these arborescent crystallizations and the ramified form in which the salts of some metals are found naturally in agate, slate, and even trap-rock, where the oxide of manganese is frequently found to have assumed similar forms. Mr. Mosley has suggested that the arborescent appearances might, perhaps, arise from the density of the solution, from the resistance of the gelatine to allow of crystallization in the usual rhombic form, and possibly to the subtle electrical or galvanic action supposed to be excited during crystallization. He has stated that some years ago he obtained from a solution of bichromate of potash tree-like forms with spreading branches and pendent rhomboids, which, under the polariscope, appeared like a tree with gems of rich colors for fruit.

CURIOUS EFFECTS OF VIS INERTIÆ.

M. Tardiret states that if a perfectly smooth and polished plate of glass, ivory, or metal, is caused to rotate with great velocity in a horizontal plane, it does not communicate its own motion to a highly-finished ball which may be placed upon it.

ENLONGATED PROJECTILES FOR RIFLED FIRE-ARMS.

In a paper recently read before the British Association by Mr. T. Aston, the author, after alluding to the improvements that have been made in war projectiles, which have resulted in the elongated form, proceeded to notice the advantages which it possessed over the old spherical shape. The elongated projectile, presenting to the resisting atmosphere a sectional area considerably less than the spherical of the same weight, is less retarded in its progress through the air. It follows, therefore, that although the spherical projectile, with a similar charge of gunpowder, is more easily set in motion, and has a greater initial velocity than the elongated form, and to that extent has at the outset an advantage, the elongated form is much better able to overcome the resistance of the atmosphere, and, owing to its superiority of momentum, preserves its progressive power for a much longer period, at the same time it is less disturbed by the varying conditions of the elastic medium through which it is propelled. In short, it has a longer and truer flight. The essential condition to the efficiency of the long projectile is, that it shall move onward with its point foremost; if it turns over in its path, it presents a large surface to the action of the air, its flight at once becomes irregular and is rapidly retarded. The action of the common spinning-top suggests at once the idea that the best mode of making the elongated projectile move steadily through the air with its point foremost is to give it rotation round its axis of progression. The rapid revolution of the body causes its inherent inequalities to be rapidly carried round a constant axis in regular order, and a kind of balance is thereby established, which gives the body a steady motion. Various plans have been from time to time tried, with the object of imparting to long projectiles a steady flight. They have been made with spiral grooves cut externally on their periphery, or internally from front to rear, in the expectation that the resisting action of the atmosphere acting on the inclined surfaces would give the requisite spinning motion. Again, they have been made very long, and furnished with fins or feathers, in order that they may be propelled on the principle of the arrow, but no practically successful results have as yet brought projectiles of this kind into use. The required object is, as is well known, readily and successfully effected by propelling the elongated projectile from a rifled barrel, that is, a tube having its interior made of such a spiral form that the projectile, while it is propelled from the breech to the muzzle, is turned round its axis of progression: a rotary motion is thus imparted, which is retained by the advancing projectile, and gives it the required steady motion. The elongated bullet was first used with rifled small-arms, either polygrooved or fluted, or, like the Enfield, having three grooves. The length, however, was limited; and various attempts were made to fire longer projectiles, compounded of various metals, and of various shapes, so that by changing the position of the centre of gravity they might be propelled point foremost. But if made beyond a certain length they were always found to turn over at moderately long ranges. Mr. Whitworth was the first to enunciate the principle that projectiles of any requisite length could be successfully fixed by giving them rapid velocity of rotation, which should be increased in proportion with their increased length. He, as is well known, uses rifles having a spiral polygonal bore, in which all the interior surfaces are made effective as rifling surfaces. The success of the elongated projectile having been established in the case of small-arms, their employment with ordnance followed as a natural consequence. Rifled ordnance were, therefore, called into existence to meet the requirements of the time. In fact, rifled cannon may be considered as a rifled musket made with enlarged proportions.

The importance of giving to ships intended for high speed the shape best suited to facilitate their progress through water is now universally acknowledged; and Mr. Whitworth considered that it was necessary to ascertain, by reasoning upon similar grounds, and by experimental research, what was the proper shape to give his projectile, so that it might be propelled through the air under conditions most favorable to precision and range. He, after numerous corroborating experiments, decided that the projectile adopted by him was the best. It has a taper front, having nearly the external section of what mathematicians term the solid of least resistance, the curve being somewhat rounded; the rear is made to taper in such proportion that the air displaced by the front is allowed readily to close in behind upon the inclined surfaces of the rear part. The middle part is left parallel to the required distance, to provide rifling surfaces, and obviate windage. The results of long and repeated trials show that this form of projectile gives much greater precision and a superiority of range, varying from fifteen to twenty-five and thirty per cent. (according to the elevation and consequent length of range), as compared with a projectile of the common rounded front and parallel rear end. At low elevations, where the range is comparatively short and the velocities great, the difference in the result of the taper and non-taper rear is not so marked as at the higher elevations, where the mean velocities of the projectiles are reduced. But at all ranges the superiority exists both in precision and velocity, as the elongated projectile, at no practical range, has a mean velocity so great as to prevent the atmosphere closing in behind it. One of the most important advantages attending the use of the taper rear is, that it gives a lower trajectory, which renders errors in judging distance of minor importance, as the projectile which skims along near the ground is more likely to hit a mark, especially a moving one, than a projectile which, moving in a more curved path, has to drop, as it were, upon the object aimed at, whose distance therefore must be accurately guessed. The taper shape of the rear is peculiarly well adapted for the proper lubrication of the gun, which is most essential for good shooting.

Various forms of elongated Whitworth projectiles, suited for special purposes, were described: tubular projectiles for cutting cores out of soft materials, as the sides of timber ships; flat-fronted, hardened projectiles, first used by Whitworth, and afterwards by Armstrong, for penetrating iron plates. It is found that these projectiles penetrate, when fixed point blank, through iron plates inclined at an angle of fifty-seven and a half degrees to the perpendicular. The edge of the flat front, though slightly rounded, takes a hold, as it were, as soon as it touches the plate, and the resistance met is merely that due to the thickness of plate, measured diagonally. Official experimental trials made on board the *Excellent* at Portsmouth showed that these projectiles penetrate readily through water, and would go through a ship's side below water-mark.

THE MOTION OF CAMPHOR UPON WATER.

Mr. Charles Tomlinson has recently presented to the Royal Society, London, a description of some very elaborate experiments made by him in explanation of the motions of small portions of camphor when thrown upon the surface of pure water. The following is an abstract of the conclusions he had deduced from his investigations: — That to succeed in the production of these movements the camphor must be thrown on the surface of clean water, in a perfectly clean vessel. That these phenomena may be also produced by certain salts, and other substances that diffuse readily over the surface of water. Thus the motions of camphor may be imitated by placing on water floating rafts of talc, tinfoil, paper, etc., smeared with or containing volatile oils, or any volatile liquid, such as ether, alcohol, chloroform, etc., provided there be a communication between such a liquid and the water. The camphor or other volatile substance, being slightly soluble in water, spreads a film over the surface of the water the moment that it comes in contact with it. The dimensions and form of this film evidently depend on those of the piece of camphor operated on, and in general the film separates more easily from broken surfaces and angles than from a smooth surface, as the broken surface of a crystal is more soluble than the natural surface. These films being constantly detached from the camphor so long as it is in contact with the water, displace each other, the preceding film being conveyed away by the adhesion of the water in radial lines, which produce motion by reaction on the fragments of camphor, causing them to rotate in the same manner as a Barker's mill. These jets or films of camphor can be rendered visible by various means, as by fixing the camphor in water, and dusting the surface lightly with lycopodium powder, when a series of currents produced by the films will be made visible. The motions of the fragments of camphor on water are greatly influenced and complicated by their mutual attraction, and by the attraction of the sides of the vessel. The film of camphor diffused over the surface of the water is very volatile, disappearing as fast as it is formed, chiefly into the air, only a very small portion being retained by the water. Hence camphor wastes away much more quickly at the surface of the water than in water alone, or in air alone, because at the surface the film is being constantly formed at the expense of the camphor, and is spread out to the united action of air and water. Whatever interferes with evaporation lowers or arrests the motions of the camphor and the allied phenomena; so, on the contrary, whatever promotes evaporation exalts these phenomena. Effects which are displayed with great energy on a bright and sunny day, are produced either sluggishly or not at all on a wet, dull, or foggy one. A fixed oil forming a film on water will displace the camphor-film, and so permanently arrest the motions of the camphor; but a volatile oil will only arrest the motions while it is present and undergoing evaporation. The motions of camphor on the surface of water are increased by the action of the vapor of benzole and some other volatile substances, such vapors condensing in the liquid form on the camphor, and being then diffused by the adhesion of the water.

EXTENT OF THE EARTH'S ATMOSPHERE.

At the British Association, 1862, Prof. Challis presented a paper on the above subject, the object of which was to show that the earth's atmosphere is of limited extent, and reasons were adduced, in the absence of data for calculating the exact height, for concluding that it does not extend to the moon. It was argued, on the hypothesis of the atomic constitution of bodies, that the upward resultant of the molecular forces on any atom, since it decreases as the height increases, must eventually become just equal to the force of gravity, and that beyond the height at which this equality is satisfied there can be no more atoms, the atmosphere terminating in a small finite density. It has been generally stated that the earth's atmosphere is about forty-five miles high, but on no definite grounds, and the estimates of the height have been very various. Against the opinion that it extends as far as the moon, it was argued that, as the moon would, in that case, attach to itself a considerable portion by its gravitation, which would necessarily have some connection with the rest, there would be a continual *drag* on the portion more immediately surrounding the earth, and intermediately on the earth itself, which would, in some degree, retard the rotation on its axis. Hence, if, as there is reason to suppose, the rotation be strictly uniform, the earth's atmosphere cannot extend to the moon. The author also stated that if by balloon ascents the barometer and thermometer were observed at two heights ascertained by observation, one considerably above the other, and both above the region in which the currents from the equator influence the temperature, data would be furnished by which an approximate determination of the height of the atmosphere might be attempted.

AUGMENTATION OF THE APPARENT DIAMETER OF A BODY BY ITS ATMOSPHERIC REFRACTION. BY PROF. CHALLIS.

For reasons given in the preceding communication, it was assumed that atmospheres generally have definite boundaries at which their densities have small but finite values. Two cases of refraction were considered: in the one, the curvature of the course of a ray through the atmosphere was assumed to be always less than that of the globe it surrounds; and in the other, the curvature of the globe might be the greater. The former is known to be the case of the earth's atmosphere; and it was supposed that, *à fortiori*, this must be the case with respect to any atmosphere the moon may be supposed to have. On this supposition it was shown that the apparent diameter of the moon, as ascertained by measurement, would be greater than that inferred from the observation of an occultation of a star, because, by reason of the refraction of the atmosphere, the star would disappear and reappear when the line of vision was within the moon's apparent boundary. The same result would be obtained from a solar eclipse. It was stated that, by actual comparisons of the two kinds of determinations, such an excess to the amount of six to eight seconds was found. This difference may reasonably be attributed to the existence of a lunar atmosphere of very small magnitude and density. The author also stated that from this result there would be reason to expect, in a solar eclipse, that a slender band of the sun's disc immediately contiguous to the moon's border would be somewhat brighter than the other parts, and advised that especial attention should be directed to this point on the next occurrence of a solar eclipse. The case in which the curvature of the path of the ray is greater than that of the globe was assumed to be that of the sun's atmosphere; and it was shown, on this supposition, that all objects seen by the rays which come from the sun's periphery are brought by the refraction to the level of the boundary of the atmosphere, whether they proceeded from objects on the surface of the interior globe, or from clouds supposed to be suspended in the atmosphere. Accordingly, the contour of the sun should appear quite continuous, and the augmentation of apparent semi-diameter will be equal to the angle subtended at the earth by the whole height of the atmosphere. The apparent diameters of the planets will, for like reasons, be augmented to a certain amount by the effect of refraction; and, on account of the great distances of these bodies from the earth, the eclipse of a satellite will take place as soon as the visual ray is bent by the interposition of the atmosphere.

ATMOSPHERIC WAVES.

One of the most important results which have flowed from recent systematized meteorological observations has been the determination of what is called the atmospheric wave, which means an ideal surface in the atmosphere at which the pressure is everywhere the same. If the atmosphere were still and undisturbed, this would be parallel to the earth's surface, and would never vary. Such, however, is by no means the case, the variation being sometimes enormous, rapid, and incessant, and strictly marking the conditions of calm and storm in the parts of the earth over which the wave is traced. One of the best illustrations of the action of this wave was afforded in the great storm which seriously injured the English and French fleets in the Black Sea on the fourteenth of November, 1854. This was by no means a local storm, as was proved by the comparison of more than two hundred and fifty reports from observers scattered all over the continent.

On the twelfth of November, 1854, the pressure of the air, which had been low, was enormously high on the line ranging from the west of England into France, reaching almost to the Pyrenees, but at various places east of this line the barometer was low. A great undulation of the air was taking place, and the ridge of a commencing wave was in the line here stated. As yet the storm had not commenced; but before four-and-twenty hours had elapsed this vast wave had moved toward the east, the north part of the crest having then reached Sweden, while the southern part had advanced far in the Mediterranean. It went through the great cities of Berlin, Dresden, and the southern part, and, having the Alps as its boundary, was lost in their windings. On each side of this crest the indications of storm were very marked.

Still another day elapsed, and the wave had now reached St. Petersburg and Dantzig, while its southern part was close to Vienna, and had entered the Adriatic, running down the coast of Dalmatia. On the fifteenth it was on the Carpathian Mountains, and on the sixteenth the crest had reached the Black Sea. Beyond that, there were no observatories to mark its progress. The storm took place when the low advancing wave glided over the gloomy waters of the Black Sea, long before the crest made its appearance. The weather is described as having been favorable enough until the fatal atmospheric wave bore down on the spot. Then, indeed, the barometer fell rapidly; but it was too late.

The high crest so curiously indicated could not be unaccompanied by depression. It commenced and was traceable at a great distance, and, in point of fact, the depression everywhere preceded the advancing wave, while another less considerable followed it. But while at the beginning the difference was small and the result unimportant, in proportion as the wave advanced toward the east, the hollow in advance became greatly deepened, or, in other words, the mercury stood very low indeed. The strength of the storm was felt where the depression reached its minimum, in the Black Sea, on the fourteenth of November. At that time the depression had been succeeded by the crest of the wave between St. Petersburg and the Dalmatian coast. The course of this storm, from its first commencement on the shores of the Atlantic till it reached the Black Sea, and the rate at which it was travelling, were matters perfectly within calculation after it had passed over the British Islands, and the time of its probable arrival in the Black Sea might have been telegraphed some forty-eight hours in advance.

VERTICAL MOVEMENTS OF THE ATMOSPHERE.

At the British Association, 1862, Prof. Hennesy stated as the result of his observations, that non-horizontal movements of the air are more prevalent, upon the whole, about mid-day, than at any other diurnal period. Their sudden and abrupt commencement is usually a precursor and always accompanies great horizontal disturbances. Their gradual and regular diminution in energy seems to point to a steady tendency in the air towards a state of convective equilibrium, and frequently precedes fine weather. In general the motion of the air is not strictly horizontal, but undulatory; and the mingling of such undulations with the effects of convection seems to point out the value of the study of the atmospherical pulse as a test of the changes of the weather.

MECHANISM OF THE HUMAN VOICE.

By means of the laryngoscope, Mr. John Bishop has succeeded in watching the movements of the larynx during the utterance of vocal sounds. When the lower tones are made, the vocal cords vibrate through their whole length. As the pitch rises, the vibrating length diminishes, and the cords are pressed more closely together. In falsetto notes, it is only the extreme end of the cord that vibrates. Moreover, the vocal cords form a kind of valve, which is situated in a tube, and acts like a reed. Thus, the organs of the voice perform the double office of reed and string. — *Proc. Royal Soc.*

Taking advantage of the laryngoscope, Prof. Czermak has succeeded in photographing the glottis, its condition during vocalization, and the changes which take place in the cords during the different chest and falsetto notes.

THE SOUNDING PROPERTIES OF ROOMS.

A correspondent of the London *Builder* presents the following ideas on the proportions of rooms for propagating sound. He says: A building of a certain height, length, breadth, and form, is required to enable an assemblage of persons to hear clearly and distinctly in every part of the room. I only know of one room in Great Britain (and I have examined many) which is as near perfection as possible, and this a concert room at Harrowgate. The following are its dimensions: —

Length of room inside	86 feet 6 inches.
Width	33 "
Height to the ceiling line	22 " 7 "
Height to centre of ceiling	24 " 2 "

The ceiling is the segment of a circle rising one foot in seven inches. There are nine sunken panels in the length of the ceiling and seven in width, each nine inches deep. There are nine large windows along the north wall, three at the east and three at the west end. On the south side there are two doors and one window, a small orchestra ten feet high, and two Doric columns on each side of the orchestra.

POWER OF WAVES.

In a paper on this subject before the British Association, 1862, Prof. Rankine stated that the mechanical energy of a wave is half actual and half potential (half being due to motion and half to elevation), and the destructive power of a wave is double of that due to the motion of its particles alone. The hydrostatic pressure of each individual particle during the wave-motion is the same as if the liquid were still.

FORMS AND ACTION OF WATER.

At the meeting of the British Association, 1862, one of the evening meetings was devoted to a lecture from the well-known physicist, Prof. Tyndall, on the "Forms and Action of Water."

The Professor dwelt at the outset on the energy of molecular forces. In the combination of oxygen and hydrogen to form a gallon of water, weighing ten pounds, an energy was expended — the atoms clashed together with a force — equal to that of a ton weight let fall from a height of 23,757 feet. In falling from the state of vapor to that of water, an energy was exerted equal to that of a ton falling from a height of 3,700 feet, or of one hundred weight from a height of 74,000 feet. The moving force of the stone avalanches of the Alps was but as that of snow-flakes compared with the energy involved in the formation of a cloud. In passing finally from the liquid to the solid state, the atoms of ten pounds of water exercised an energy equal to that of a ton weight falling down a precipice five hundred and fifty feet high. The lecturer then halted to consider some of the phenomena connected with water in its vaporous state. Its action upon radiant heat was extraordinary. Though forming only about five-tenths per cent. of the entire atmosphere, for every ray of terrestrial heat struck down by the air, fifty, sixty, or seventy rays were destroyed by the aqueous vapor. The vapor of the lecture-room was shown by condensing it on the surface of a vessel containing a freezing mixture, on which it precipitated itself in such quantity that, when scraped off, a snowball was formed of the condensed vapor. Aqueous vapor was the "barb" of our atmosphere; it permitted the solar rays to reach the earth, but intercepted the terrestrial rays in their escape towards space. The Desert of Sahara showed us what would be the effect of its removal. There, where the "soil is fire and the wind is flame" during the day, the nights are intensely cold, — ice, in fact, has been known to be formed. Were the aqueous vapors removed from the air which covers England, no doubt a single summer night would destroy all plants incapable of bearing a freezing temperature. The Professor then dwelt briefly on the liquid state of water, and passed on to consider its solid form. Ice was chosen, and shown to be eminently brittle. Pieces of it, when placed together, froze together. This freezing was shown to occur in hot water. The ice was scraped to fine powder, and the frozen powder, placed in a mould, was squeezed to a sphere of hard ice by the pressure. Cups were formed from the ice powder; and in the presence of such experiments it was easy to see how the snow of the Alpine mountains should compress itself to ice, and how the ice could be squeezed through the moulds formed by the valleys. From existing glaciers the Professor passed on to those of a former epoch, and showed that a diminution of the sun's heat would not account for them. They were as much a proof of heat as of cold. They were a proof of powerful condensation, but to produce the vapor for condensation an enormous expenditure of heat was necessary. To produce a glacier required as much heat as would raise five times the weight of that glacier of cast iron to its melting point. What was wanted, then, to produce the glacial epoch was not a less powerful sun, but a more powerful condenser; and the speaker conceived that this was most easily obtained by assigning to the Alps a greater mean elevation than they now enjoy. For ages they have been planed down by glaciers and by atmospheric denudation generally. The valley of the Po is overstrewn with their ruins; by the wear and tear of time they must have been lowered, and hence rendered incompetent to condense the vapors necessary to produce the glaciers of a by-gone age.

SCIENTIFIC BALLOON ASCENTS.

Under the auspices of the British Association, eight balloon ascensions for scientific purposes have been recently made by Mr. Glaisher, the well-known meteorologist. In a communication made to the British Association, 1862, Mr. G. detailed the objects sought to be attained in these experiments, as follows: —

The primary objects of the experiments were, the determination of the temperature of the air and its hygrometric state at different elevations, up to five miles. The secondary objects were, to compare the readings of an aneroid barometer with those of a mercurial barometer up to five miles; to determine the electrical state of the atmosphere; to determine the oxygenic condition of the atmosphere by means of ozone papers; to determine the time of vibration of a magnet on the earth and at different distances from it; to determine the temperature of the dew-point by Daniell's dew-point hygrometer and Regnault's condensing hygrometer, and by the use of the dry and wet bulb thermometers as ordinarily used, and by their use when under the influence of the aspirator, so that considerable volumes of air were made to pass over both bulbs at different elevations, as high as possible, but particularly up to those heights where man may be resident, or where troops may be located, as in the high lands and plains of India, with the view of ascertaining what confidence may be placed in the use of the dry and wet bulb thermometers at those elevations by comparison with those found directly by Daniell's and Regnault's hygrometers, and also to compare the results as found by the two hygrometers together; to collect air at different elevations; to note the height and kind of clouds, their density and thickness, at different elevations; to determine the rate and direction of different currents in the atmosphere, if possible; to make observations on sound; to note atmospherical phenomena in general, and to make general observations.

Mr. G. then gave a detailed account of the instruments used, and the circumstances connected with the various ascents, all of which were made in the vicinity of London. In an ascent on the 17th of July, a height of 26,177 feet was reached; and in the descent a mass of vapor of 8,000 feet in thickness was passed through, so dense that the balloon was not visible from the car. At starting, the temperature of the air was fifty-nine degrees; at four thousand feet, forty-five degrees; and descended to twenty-six degrees at ten thousand feet; and then there was no variation of temperature between this height and thirteen thousand feet. "During the time of passing through this space, Mr. Coxwell, my companion, and myself both put on additional clothing, feeling certain that we should experience a temperature below zero before we reached an altitude of five miles; but, to my surprise, at the height of 14,500 feet, the temperature as shown by all the sensitive instruments was thirty-one degrees, and at each successive reading, up to 19,500 feet, the temperature increased, and was here forty-three degrees. When we had fallen somewhat, the temperature again began to decrease and with extraordinary rapidity, and was sixteen degrees, or twenty-seven degrees less than it was twenty-six minutes before. At this time, about eleven A. M., we were at a height of five miles."

In an ascent on the 20th of August, the balloon hovered for a long time over London, the hum of which was very audible. When the city was lighted at night it presented the appearance of an enormous conflagration. The most important ascent, however, was made on the 5th of September, in which a greater elevation was attained than had ever before been reached by human beings. The ascension commenced at one P. M., the balloon containing sixty thousand cubic feet of coal-gas, of specific gravity 0.340; ordinary coal-gas being 0.470. At the surface of the earth, the temperature of the air was fifty-nine degrees Fahrenheit; at the height of one mile, thirty-nine degrees Fahrenheit. Shortly after attaining this altitude, the balloon entered a cloud eleven hundred feet in thickness, in which the temperature fell to thirty-six Fahrenheit, and the air was saturated with moisture. When a favorable opportunity presented itself, a photograph camera, which had been provided with a set of extremely sensitive dry plates, was brought into requisition for the purpose of taking photographs of the clouds, but the balloon was ascending with such velocity — owing to the expansion of the gas and the lighter character of the atmosphere — that Mr. Glaisher failed to obtain a single picture. At three miles high, the machine was rising rapidly, the sixty thousand feet of gas had expanded to ninety thousand, and was oozing out of the safety-valve at the bottom of the balloon. The rate of ascent was stated by Mr. Glaisher to have been as follows: — "We reached two miles in height at 1.21; three miles at 1.28; and four miles at 1.39. In ten minutes more we had reached the fifth mile, and the temperature had passed below zero, and then read minus two degrees. Up to this time, I had taken observations with comfort. I had experienced no difficulty in breathing, whilst Coxwell, in consequence of exertions in throwing out ballast, had breathed with difficulty for some time." Very soon after this, however, Mr. Glaisher began to feel unpleasantly. Describing what then occurred, Mr. G. continues: — "Mr. Coxwell ascended into the ring, and I endeavored to reach some brandy which was lying on the table at a distance of about a foot from my hand, but I was unable to do so. My sight became dim. I looked at the barometer, and saw it between ten and eleven inches, and tried to record it, but was unable to write. I then saw it at ten inches, still decreasing fast, and just managed to note it in my book, — its true reading, therefore, was about nine and three-fourths inches, implying a height of about twenty-nine thousand feet. I was losing all power, and endeavored to rouse myself by struggling and shaking. I essayed to tell Mr. Coxwell I was becoming insensible, but I had lost the power of speech. I saw Mr. Coxwell dimly in the ring; it became more misty, and finally dark. I was still conscious, and knew I should soon be insensible, and I suddenly sank as in sleep. On recovering consciousness, I heard Mr. Coxwell say, 'What is the temperature? Take an observation, — now try.' I could neither see, move, nor speak; but I knew he was in the car, trying to rouse me. I then heard him speak more emphatically, — 'Take an observation. Now do try.' I then saw the instruments dimly, and Mr. Coxwell very dimly; then more clearly; and shortly afterwards said to Coxwell, — 'I have been insensible;' and he replied, 'You have, and I, nearly.' I recovered somewhat quickly, and Mr. Coxwell said, — 'I have lost the use of my hands; give me some brandy to bathe them.' His hands were nearly black. I saw the temperature was still below zero, and the barometer reading eleven inches and increasing quickly. I resumed my observations at 2.7, recording the barometer reading 11.53 inches, and the temperature minus two degrees. I then found that the water in the vessel supplying the wet bulb thermometer, which I had by frequent disturbance kept from freezing, was one mass of ice. Mr. Coxwell then told me that whilst in the ring he felt it piercingly cold; that hoar-frost was all round the neck of the balloon; and on attempting to leave the ring he found his hands frozen, and he had to place his arms on the ring and drop down; that he found me motionless, with a quiet and placid expression on the countenance; that he at first thought I was resting myself; that he then spoke to me without eliciting a reply, and then observed my arms hanging by my side, and my legs extended, and found I was insensible. He then felt that insensibility was coming over himself, and that he could not assist me in any way; that he became anxious to open the valve, that his hands failed him, and he instantly seized the line between his teeth, and pulled the valve open two or three times, until the balloon began to descend." In the course of a few minutes, Mr. Glaisher revived, and by the time that he reached the earth the effects of his faintness had entirely disappeared. While Mr. Glaisher was unconscious, Mr. Coxwell happened to cast his eyes on the needle of the aneroid barometer, and when Mr. Glaisher recovered he informed him of its position. From this observation, Mr. Glaisher estimates that they attained a height of fully six miles. At a height of five miles, the mercury stood at minus five degrees; the self-registering thermometer indicated that it had been as low as minus twenty, or fifty-two degrees below freezing point. Among the articles taken up in the balloon was a quantity of water, and until they reached a height of five miles Mr. Glaisher kept it from freezing by occasionally stirring it with a small ladle. When he recovered his consciousness he found that the water had been frozen into a solid block of ice, and it remained in this condition for more than an hour and a half after he reached the earth.

In this ascension, six pigeons were taken up. One was thrown out at the height of three miles; it extended its wings and dropped like a piece of paper; a second, at four miles, flew vigorously round and round, apparently taking a dip each time; a third was thrown out between four and five miles, and it fell downwards; a fourth was thrown out at five miles, and it fell downwards; a fifth was thrown out at four miles when descending; it flew in a circle, and shortly alighted on the balloon. The two remaining pigeons were brought down to the ground. One was found dead, and the other, a carrier, had attached to its neck a note. It would not, however, leave, and, when cast off the finger, returned to the hand. After a quarter of an hour it began to peck a piece of ribbon by which its neck was encircled, and it was then jerked off the finger, and it flew with some vigor.

Compared with this aerial voyage, all other balloon ascensions sink into insignificance. Gay-Lussac attained an elevation of about four miles; Mr. Glaisher on two occasions rose considerably above this elevation, and on the last ascent, as we have already stated, probably attained a height of six miles. Had it not been, moreover, for the presence of mind of Mr. Coxwell the voyagers would have shot up into an atmosphere so thin that respiration could not be sustained, and in the end the expansion of gas would probably have burst the balloon; or, if the safety-valve had been sufficiently large to allow for that expansion, they might have been carried into space and numbered among the victims on the altar of science.

The London *Times*, in commenting on this ascension, says:—"Courage is a thing of habit, and sometimes it fails altogether just as soon as it is out of the field of its habit. Your bold rider is one who has begun young; his whole body, with its muscles and sinews, has accommodated itself to the back of a horse, and acquired an intuitive and unconscious balance. But take him off of his horse, and, unless he has the *principle* of courage within him, he is an ordinary mortal, and no more likes breaking his neck than a quiet humdrum citizen. A soldier is accustomed to courage in company, with gallant fellows around him; but that makes an immense difference. Company is both inspiriting and relieving; it divests courage of its horrors and gloom. It is, therefore, much easier to be bold in company. The feats of a man of science give you a better guarantee for real courage, because they are solitary, deliberate, calm and passive. It is true he has his enthusiasm which helps him, and he has his field of courage to which he has accustomed himself. But every new venture, every fresh essay upon this field, is a solitary effort and impulse with him. He has to fight alone and by himself against the faintness of nature, without men shouting, or flags flying, or trumpets clanging around him. He faces the invisible forces of nature, the gas that explodes or the poison that penetrates, with the countenance of a student and philosopher, and is at the disadvantage of having to be fully conscious and self-possessed, instead of having the aid of the swing and the impetus of passion. The cool feats of our scientific men are known to us all — such as that of Sir Humphrey Davy inhaling a particular gas with an accurate report every minute or two of its successive effects upon his brain and senses; but the aerial voyage of Messrs. Glaisher and Coxwell deserves to rank with the greatest feats of our experimentalizers, discoverers, and travellers. It is true that these gentlemen have not brought down a very comfortable or inspiring report of the upper world into which they have penetrated; but they have, nevertheless, furnished one more striking and impressive scene to the history of science. They have shown what enthusiasm science can inspire, and what courage it can give. If the man, as the poet says, had need of 'triple steel about his breast' who first launched a boat into the sea, certainly those had no less need of it who first floated in the air six miles above the surface of the earth."

From a mean of all his observations, Mr. Glaisher presented to the British Association the following table, showing the mean temperature of the air at every five thousand feet of elevation above the level of the sea in each high ascent: —

Height above the level of the Sea.	Mean Temperature of the Air.					Decrease of Temperature for an Increase of Height of 5,000 feet.
	July 17.	Aug. 18.	Aug. 21.	Sept. 5.	Mean.	
Feet.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
0	61.2	69.6	62.0	62.2	63.8	....
5,000	39.7	48.0	43.3	41.4	43.1	20.7
10,000	28.0	40.7	32.0	31.0	32.9	10.2
15,000	31.0	31.1	19.0	21.0	25.7	7.2
19,500	42.2	....	....	....	....	....
20,000	33.0	25.9	....	10.6	23.2	2.5
25,000	16.0	23.9	....	0.0	13.3	9.9
30,000	....	....	....	-5.3	....	....
Decrease of Temperature for an increase of Height of 25,000 Feet.	44.9	45.7	....	62.2	50.5	....

The results on July 17 are perfectly anomalous. Up to 10,000 feet the decrease accords with the other days of experiments; but from 10,000 feet the results are perfectly surprising, and continue so up to more than 20,000 feet. Above 25,000 feet they are again accordant. If we suppose that up to 10,000 feet and again at 25,000 feet the results are not abnormal, by continuing the curve joining these two portions, and then reading, we should have the following readings, namely: at 0 feet the mean temperature was 61.2°; at 5,000 feet, 39.7°; at 10,000 feet, 27.5°; at 15,000 feet, 22.7°; at 19,500 feet, 20.0°; at 20,000 feet, 19.5°; at 25,000 feet, 16.3°. Then the measure of disturbance would be as follows: — At 10,000 feet, 0.5° in excess; at 15,000 feet, 8.3° in excess; at 19,500 feet, 22.2° in excess; at 20,000 feet, 13.5° in excess; at 25,000 feet, 0.3° in defect. The numbers in the last column of the table show that the average decrease of temperature in the first 5,000 feet exceeds 20°, and in the next 5,000 feet is but little more than 10°. The numbers in the lowest line of the table show that the average decrease of temperature for 25,000 feet is 51° nearly. From these numbers it seems that two-fifths of the whole decrease of temperature in five miles takes place in the first mile, and therefore that the decrement is not uniform with the increment of elevation.

Mr. Glaisher then spoke upon the electrical state of the air, which he found charged with positive electricity, decreasing in amount with elevation. With respect to ozone, he said that none was shown in the earlier ascents, but that large quantities were shown in the latter, and attributed the deficiency in the former to bad paper. He remarked, that diminished pressure exercised a very different influence upon different individuals, dependent probably upon temperament and organization; that the effect of high elevation was different upon the same individual at different times; that the time of vibration of a magnet was somewhat longer at high elevation than on the earth; that different notes and sounds pass more readily through the air than others, instancing that the barking of a dog can be heard two miles high, and the shouting of a multitude not one mile. The author concluded his paper with the following remarks: — "These eight ascents have led me to conclude, first, that it was necessary to employ a balloon containing nearly ninety thousand cubic feet of gas; and that it was impossible to get so high as six miles, even with a balloon of this magnitude, unless carburetted hydrogen, varying in specific gravity from three hundred and seventy to three hundred and forty, had been supplied for the purpose. It is true that these statements are rather conflicting when compared with those made by one or two early travellers who professed to have reached some miles in height with small balloons. But if we recollect that at three and three-quarter miles high a volume of gas will double its bulk, we have at once a ready means of determining how high a balloon can go; and in order to reach an elevation of six or seven miles it is obvious that one-third of the capacity of the balloon should be able to support the entire weight of the balloon, inclusive of sufficient ballast for the descent.

"It has been stated by an aëronaut of experience that strong opposing upper currents have been heard to produce an audible contention, and to sound like the '*roaring of a hurricane.*' Now, the only deviation we experienced from the most perfect stillness was a slight whining noise in the netting, and this only when the balloon was rising with great rapidity. The balloon itself, as it descends, flaps about occasionally; but this occurs when it is in a collapsed state, and very likely it was under similar circumstances, and perhaps during a rapid descent, that the flapping of the lower part of the balloon was mistaken for a roaring wind. I may also state that the too readily accepted theory as to the prevalence of a settled west or north-west wind was not confirmed in our trips; nor was the appearance of the upper surface of the clouds such as to establish the theory that the clouds assume a counterpart of the earth's surface below, and rise or fall like hills and dales."

The principal results of his observations Mr. Glaisher summed up as follows: — That the temperature of the air does not decrease uniformly with height above the earth's surface, and that, consequently, more elucidation upon this point is required, particularly in its influence on the laws of refraction. That an aneriod barometer can be made to read correctly, certainly to the first place, and probably to the second place of decimals, to a pressure so low as five inches. That the humidity of the atmosphere does decrease with the height, with a wonderfully increasing rate, till at heights exceeding five miles the amount of aqueous vapor in the atmosphere is very small indeed. Mr. Glaisher also asserted "that observations up to three miles high, even of a delicate nature, can be made as comfortably in a balloon as on the earth; that at heights exceeding four miles they cannot be made quite so well, because of the personal distress of the observer; that at five miles high it requires the exercise of a strong will to make them at all. That up to three miles high any person may go into the car of a balloon who is possessed of an ordinary degree of self-possession. That no person with heart-disease or pulmonary complaints should attempt four miles high. But, at the same time, it must be borne in mind that I am concluding that the balloon is properly handled."

In the discussion that ensued, Mr. Glaisher read a letter from a French scientist, M. Simons, offering to go eleven miles high, and inviting Mr. Glaisher himself to ascend eight and a half miles with him. Mr. Glaisher said he had no doubt that by taking up sufficient oxygen a higher point might be attained, but he (Mr. Glaisher) thought the risk too great. Colonel Sykes said that after Mr. Glaisher became insensible, Mr. Coxwell must have risen to the elevation of at least seven and a half miles, and was not otherwise affected than by the cold benumbing his hands. He thought there was not, after all, so much danger, and that the sensations experienced resulted from the particular idiosyncracy of the individuals. He hoped the Association would sanction further experiments, and they need be under no apprehension as to the danger of higher ascents. Dr. Drosier thought the utility of reaching high altitudes was undisputed. Several physical forces had contributed to the loss of sensation experienced by Mr. Glaisher: the first and least effective was cold; next, the diminution of oxygen; and, last and most important, the diminution of pressure upon the surface of the body, and consequently of the pressure of the blood upon the brain, which caused syncope. This he proposed to remedy by a horizontal position, or more effectually by an air-tight covering for the body containing atmospheric air, from which, however, the head might be excluded.

In a recently published letter on Messrs. Glaisher and Coxwell's aerial experiments, Sir John Herschel says: — While congratulating these gentlemen on the narrow escape with their lives from so unheard-of a fate as that which awaited them had Mr. Coxwell's teeth been ever so little less tenacious, I must be allowed to demur to the conclusion that the height so attained is to be regarded as the limit of what man can ever expect to reach (or reach with safety), which seems to be Mr. Glaisher's opinion; and I would throw out the suggestion, that were the aëronaut provided with a vessel containing a very moderate number of cubic feet of oxygen gas condensed under a pressure of four or five atmospheres, with the means of letting it out, in small quantities at a time, into a breathing-bag from which he might inhale the pure element at perfect ease, all danger of asphyxia would be avoided, and a much greater altitude safely attained; while his strength might possibly be sustained by a supply of that wonderful stimulant, the Peruvian *coca* leaf. As the proportion of oxygen in ordinary atmospheric air is no more than one-fifth of the total volume, and as no inconvenience is experienced in breathing air of half the ordinary density, it is evident that a sufficiency of oxygen to sustain the full vital power would be thus obtained under a barometric pressure of three inches of mercury, or one-tenth of that at the surface of the earth, which would correspond to a height of about 60,700 feet, or 11½ miles, calculating on a decrement of temperature of 10° Fahr. per mile, and a temperature of 60° at the earth's surface."

LAMONT'S NEW THEORY OF ATMOSPHERIC VAPOR. BY ALEXANDER S. HERSCHEL, B. A.

The experiments of Dr. Dalton on the pressure of vapor rising from the surface of water at different temperatures, in free space and in space enclosing air, led to conclusions which have since been received by the compilers of meteorological tables, but which are questioned by M. Lamont, and shown by his experiments to be in some degree fallacious. The vapor of boiling water, or of water at 100° Centigrade, is familiarly known by the vibrations of the lid of a kettle, and by the formation of bubbles upon the surface of the heated water, to have the pressure of the incumbent atmosphere. The bubbles which rise to the surface of water boiling in an open vessel enclose within their pellicle a vapor whose tension or elastic force is exactly equal to that of the equally heated air which surrounds their envelope, and burst so soon as the quantity enclosed exceeds a capacity proportioned to the thickness of the film. The experiments of Dalton proved that the vapor so enclosed was lighter than the air surrounding, in very nearly the proportion of two to three. It follows, by Mariotte's law of equable expansion of gases or vapors by heat, that such vapor and such air exposed to any superior equal temperature will have to each other the same proportion, in density, of two to three; but a further deduction from the experiments of Dalton is this, that water boiled in a partially exhausted receiver of air will give rise to bubbles which enclose a vapor having equally a proportion in density of two to three to the adjacent air. In short, the vapor of water and common air, wherever these subsist at a common temperature and pressure, are always in the proportion in density of two to three one to the other. We here consider the case of water boiling in air. The pressure of the incumbent air being in this case the exact measure of the elastic force or tension of the vapor emitted by the water at boiling temperature, a table is readily constructed to exhibit the vapor tension of water of given temperature. Conceive a globe, completely exhausted of air, to contain a quantity of water, not too small, and to be raised to a certain temperature in the open air; this globe will have a tendency to explode or to collapse, according as the temperature is above or below 100° Centigrade. If the atmospheric pressure about the globe be only one-half of the ordinary pressure of the atmosphere at the sea level (as, for instance, on the summit of Mont Blanc), the globe will have similar tendencies according as its temperature is above or below 82° Centigrade. And so, for higher and lower pressures of the atmosphere without, there will be required higher or lower temperatures of the water globe to equilibrate from within the pressure from without. Such a table, expressing the pressure of pure vapor arising from water of given temperature, has been constructed with extreme accuracy by Mr. Regnault; and it results that, by exceedingly rapid methods of exhaustion, water may be made to freeze in the very act of boiling, ice or snow being forms of water which do not in the least interrupt the regular march of the numbers of the table.

Conceive again a sealed globe to enclose perfectly dry air of a given temperature and pressure, and likewise a vessel freely dilatable, including water in sufficient quantity. If the temperature of the globe be high, and the pressure of the air within it be small, the water so included will boil, and the temperature being exactly maintained, the vessel will enlarge until the incumbent air is so compressed in space as to exert exactly the pressure of the vapor upon the external surface of the vessel. The pressure which now obtains within the globe is that due to the temperature of the water, according to the value assigned in the table before mentioned. M. Lamont assures us, from experiments, that the pressure will maintain this value if the walls of the including vessel be now removed. Dr. Dalton, however, deduced from his experiments a different rule. On removal of the partition supposed to separate the gaseous fluids, more aqueous vapor will be generated in proportion to the space occupied by the air, it will cross the boundary and fill that space *as if it were a vacuum;* the air at the same time will cross the boundary and expand into the space engaged by aqueous vapor *as if it were a vacuum*, and a pressure will result, the sum of that due to the temperature of the water and that of the air originally enclosed.

M. Lamont has found that a globe connected with an iced receiver by a tube one line in diameter may for two hours be occupied by water at a temperature of 100° Fahrenheit without signs of distillation taking place. Yet the pressure within the globe and receiver M. Lamont found to be compounded of that of the heated air and of the aqueous vapor with which the aerial space of the globe was saturated (by convection). This experiment is proof sufficient, in the opinion of M. Lamont, that the particles of vapor and of air are not, as in the theory of Dalton, indifferent one to another as grains of dust, but exert upon one another a mutual and permanent reaction. Whereas the aqueous particles are incapable, at low temperatures, of exerting those pressures by which they might assume among the particles of air positions of equal and independent action, M. Lamont advocates a view that an atomic combination arises between these diverse particles, causing to the saturated air a character of humidity. This character he believes to be imparted to the air by actual contact only with the source of vapor, and not by any transfer of the particles of vapor among the particles of air.

NEW FACTS IN REGARD TO SOAP-BUBBLES.

In a recent communication to the French Academy, M. Felix Plateau, the younger, states that having been requested by his father to throw away a liquid of a bad quality which had been employed to produce films, he endeavored to make it form a sheet of liquid in its descent, when to his surprise it took on the shape of a large bubble, and fell slowly. He repeated the experiment a good many times with soap-suds, and sometimes succeeded in making as many as fifteen bubbles at a time. He recommends a hemispherical vessel about five inches diameter, holding a considerable quantity of the fluid, which should be thrown at an angle of forty-five degrees with the horizon, and have a spinning motion communicated to it. "In this experiment," says M. Plateau, "my father sees an argument in support of the vesicular state of the vapors in clouds. In fact, one of the principal objections urged against this hypothesis consists in the impossibility of conceiving how the molecules of the vapor could, whilst it was passing to the liquid state, aggregate together so as to form envelopes enclosing air. Now, we see that such an aggregation in closed envelopes is not immediately necessary; it is sufficient that the molecules of water should unite in open sheets of any figures and curvatures; each of these lamellæ will immediately close so as to give rise to a vesicle. Doubtless the character of these lamellæ is itself not easily conceived; but it appears at least much more admissible than the entire formation of the vesicles."

At a recent meeting of the Royal Society, London, Dr. Frankland exhibited a series of very beautiful experiments devised by M. Plateau, designed to show the optical and mechanical properties of thin films. The films are obtained by means of a solution of one part of pure oleate of soda in fifty of water; three parts of this solution are then mixed with two parts of glycerine. The liquid thus obtained is capable of being blown, by means of a common tobacco-pipe, into bubbles of a very large size and great permanency. Dr. Frankland stated that he had succeeded, by means of a blow-pipe bellows, in obtaining a bubble nearly nineteen inches in diameter. When inflated with air these bubbles often last more than twenty-four hours; but when the breath is employed, the oleate of soda is slowly acted on by the carbonic acid expired, and their duration is limited to three or four hours.

A series of these bubbles, about six inches in diameter, were placed on a number of glass rings situated in a line, and on a ray of light from the electric lamp being transmitted through the series, their beautiful iridescent colors were developed in the most magnificent manner.

Other bubbles were inflated with a mixture of eight parts of air and one part of coal gas, which, by overcoming the specific gravity of the film, enabled the bubbles to float in the atmosphere so as to be wafted by the slightest current. The tenacity of the film was shown by allowing drops of water to fall through the bubbles, which could be accomplished without breaking them.

By dipping small wire cages, forming the outlines of geometrical solids, into the mixture of oleate of soda and glycerine, plane films were produced intersecting each other in various directions in the interior of the wire frames. Many of these offered very remarkable geometrical combinations; the wire outline of a tetrahedron, for example, on being withdrawn from the solution, was shown to contain six triangular films, all meeting at the centre of the figure.

RUTTAN'S "EXHAUSTION" PRINCIPLE OF VENTILATION.

Mr. Henry Ruttan has recently published in New York a work designed to illustrate a peculiar system of warming and ventilating dwellings, upon what the author calls "the exhaustion principle," and which it is claimed has been applied with success on railroad cars.

On the subject of heating different houses, Mr. Ruttan states that the difference of locality and size of different apartments in houses is so great that it is utterly impossible to lay down any rule in the generation of heat, but he gives the following advice, as derived from experiment, respecting the heating of rooms in relation to their depth between the ceiling and floor. He says: "People are generally impressed with the idea that it is the ground area, or lateral measurement of a room, by which they are to be guided in arranging for its warming, but this is not correct; it is the height by which they should be chiefly governed. When I tell you that it takes about double the quantity of fuel to warm a room twelve feet high that it takes to bring one of the same lateral measurement and ten feet high to the same temperature, you may be surprised, yet this is a fact which I have proved by many experiments." In another place he says: "We must have no rooms over ten feet high, and nine feet would be better, except in the cases of churches and theatres, where special provision is made for warming. I know there will be strong opposition to any such proposition, for hitherto high ceilings have been looked upon as a sort of substitute for ventilation, and as the need of ventilation was felt more in cities than in the country, the ceilings of apartments were made higher there, and from this it has grown into the fashion. But if thorough ventilation can be secured, the great advantage a low ceiling possesses over a high one in the saving of fuel, as well as in the rapidity of a change of air, will, I think, induce those people who are governed by common sense to adopt it. That this thorough ventilation can be secured, there is not a shadow of doubt."

As it respects the forms of hot-air furnaces, Mr. Ruttan asserts that those manufacturers who increase the heating surface of their productions by pipes, corrugated, or otherwise, act upon unphilosophical principles. The best shape of an "air-warmer" for buildings, he says, "is that which presents the greatest surface to the centre of the fire, and that being globular, this is the form most efficient and economical for warming houses by air." And to sum up the question of heating, he says: "If we want our houses warmed and ventilated we must supply a brisk and easy flowing body of air. The air should pass out of the room at about sixty degrees temperature, and this will make it necessary to take it from the 'air-warmer' at ninety or one hundred degrees in an ordinary winter's day, and with an ordinary sized house, say forty feet square. In a very cold day, when the air is liable to lose its heat much faster from the increased cooling of the walls, the warm air should be brought in at a somewhat higher temperature. There is a great advantage in being able to bring in the warm air at that comparatively low temperature, as thereby all danger of injuring it by overheating (as is often the case with hot-air furnaces) is prevented."

By the common mode of heating and ventilating buildings by means of hot-air apparatuses, the cold air is taken in from below and the warm air let out above. In churches, houses, and other buildings the furnace or heater is placed in the basement, and the warm air is conducted upward through openings in the floors. By this system, the upper stratum of air in rooms is frequently too warm, while the stratum near the floor is quite cold. As the feet of persons are most liable to become cold, it is more necessary to have warm floors than ceilings to obtain the greatest amount of comfort. By the Ruttan system this is secured in a peculiar manner, which may be called the inverted siphon method. To give a general idea of it, suppose there are three rooms placed above one another, and that the two upper ones have floors laid with an open space of a few inches wide extending along their sides. A chimney or shaft extends from the basement in the usual manner, but has only one opening inside, and that is upon the lower room floor. This opening is covered with a sliding door, and no air can get to the outside except by passing through this door and up to the top of the chimney. Now, supposing warm air is admitted from the heater by openings in the ceiling of the upper room (the very reverse of the common method), no current will be produced while the door of the chimney in the lower space or apartment is shut; but whenever this is opened the warm air presses downward, passing through the spaces along the sides of the floors, then through the opening in the chimney, and up thence to the atmosphere outside. By this ingenious method a natural draught is produced; the warm air is taken in from above, carried down through the floors, and from thence outside, sweeping all the foul air with it. It will be understood that warm fresh air is admitted constantly from above. When air is heated in a room to 75.46 degrees above that of the atmosphere outside, its pressure is increased two pounds on the square inch. We may judge from this of the expansive force which it possesses to produce a downward draught through rooms to the opening in the shaft below, thence to escape into the atmosphere. By this method of heating and ventilating, the stratum of air near the floors of apartments is maintained at the same temperature as that near the ceilings, and indeed the temperature in every part of the room will be nearly uniform. In apartments constructed to carry out this system, the floors, which are laid with an open space of a few inches along the sides, have a perforated "base-board," which may be of iron and of an ornamental character.

NOTES ON CALORIFIC PHENOMENA.

The following is an abstract of a paper read before the Manchester Philosophical Society by Mr. J. C. Dyer: —

The author states that the *essences* of matter, their number and their forms, are only known to us by their observed properties and mutations; that conflicting theories on physics arise from the various interpretations given to the same phenomena; and if unable to reconcile such differences, further inquiry, with that view, may not be improper, whilst the laws of nature rest on debatable grounds. That practically *matter*, in its aggregate, is found to consist of two sorts or classes, — the "ponderable" and the "imponderable," — gravity and elasticity serving to distinguish their respective inherent properties. That as no tests of weight or measure can apply to the latter, its mutations and action on other bodies are the sole means we have of forming any judgment concerning its agency in the laboratory of nature. That the calorific element, or *heat*, is assumed to be the *one* "sole imponderable element which pervades matter and space throughout the universe," and *it* constitutes the elastic forces reacting upon and *balancing* the gravitating forces in all other bodies. This *elemental state* of *heat* must be taken as distinct from its other *three* states of sensible, radiating, and specific heat, commonly recognized. That elemental heat is acted upon by mechanical and chemical forces, and the changes which it undergoes from the one to the other conditions of heat give rise to atmospherical phenomena, known as electrical, magnetic, and optical, as also to the entire range of meteorological changes, as set forth in the paper. That, by the mechanical forces of the earth's motion in its orbit and diurnal rotation acting upon the elemental medium, its equilibrium is disturbed, and motions generated which afford rational explanations of the luminous and ordinary electrical and magnetical conditions of the atmosphere, as indicated by their respective meteors. That, by the action of chemical forces, great mutations of heat are continually going on; for example, the heat which on a vast scale abounds in vapor is given out as clouds are formed, and accounts for the positive and negative electricity, and also, when redundant, for lightning from thunder-clouds. As much heat is evolved above the clouds, where cold prevails, it must become elemental or neutral there, and justifies the inference that it is identical with the electric fluid, as above said. That electricity and magnetism are but diverse actions of one element, has been proved, and their action on matter proves their materiality. The mechanical and chemical action of light proves its materiality also; and that light and heat are identical has been clearly established. The plurality of imponderable elements is, therefore, disproved by the fact that mutations of the one element fully account for all of the phenomena attributed to several. The gravitating and elastic properties of matter constitute their statical and moving forces, forever balancing each other. The former of these forces would consolidate the material universe "with lightning speed," but for the reaction of the latter force. There is no reason *why* the force of gravity should be measured by the established laws of falling bodies, except that *experiment* has shown the velocities actually attained by them in *vacuo*. But this vacuum is the absence of air *only*, not that of the "elastic medium;" and it is this that holds the poise of matter throughout illimitable space.

NEW APPLICATION OF THE THERMOMETER.

Every one accustomed to the use of the thermometer must be familiar with the fact that it gives no account of the effects of various temperatures, draughts, and damp upon the sensations. During one of Mr. Glaisher's recent balloon ascensions a temperature of seventeen degrees was felt to be *warm*, because the voyagers had just quitted a region where the instrument registered some degrees below zero. So in leaving a room heated to eighty or ninety degrees, a temperature of sixty degrees will be felt to be cold. It is one of the advantages of the thermometer that it has no sensations, yet it would be an advantage if we could sometimes use it to measure the magnitude of those influences which affect sensation as to heat and cold, and the mode of so using it is very simple. A few years since Dr. Jonathan Osborne communicated to the British Association some experiments on the use of a *heated* thermometer as a means of instructing the physician as to the influence of climate on health, but the subject was neglected, and he has again called attention to it in an essay on the subject in the *Dublin Journal of Medical Science*. One use of the heated thermometer is to explain the difference observed in the effect on invalids of climates having similar thermometrical characteristics. Thus the western coast of Ireland has a mild and genial climate if tested by the thermometer only, yet the trees are stunted in their growth by the constant wind blowing from the Atlantic, and invalids do not reap such advantages from a residence there as would be predicated by trusting to the thermometer only. So, during a severe frost, if the air is still, the cold is not much felt, but if there is a moderate breeze or a gale, even with a moderate rise of the thermometer, the sensation of cold is keenly felt, and, in point of fact, as regards health and comfort, the temperature is lower, though the thermometer says differently. The author thus describes the principle on which the use of the heated thermometer depends: — "The bulb being heated up to ninety degrees Fahrenheit, represents the heat of the surface of the human body; when in this state it is exposed to a cooler medium, whether air or water, or mixture of both, as moist air, and allowed to cool to eighty degrees Fahr.; the time for cooling these ten degrees represents (inversely) the cooling power exerted by that medium, whatever it may be, or however applied. This cooling power is derived from other agencies besides difference of temperature, as from radiation of the neighboring objects, conducting power of the surrounding medium, and more especially from currents causing various proportions of it to be brought into contact with the heated body within a given time. Now, these agencies have their combined results exhibited in the degree of rapidity with which the cooling is effected. Placed, as we are, in a medium, with few exceptions, always below eighty degrees, we are constantly undergoing a process of cooling. In our ordinary clothing we feel just comfortable at fifty-six degrees indoors; but when exposed to a current of air, even at the same temperature, we feel cold in proportion to the force of the current, or in proportion to the conducting power imparted to it by increased moisture. Both these are agencies of which the thermometer takes no notice. Its indications are furnished by the contractions or expansions of a fluid, whether mercury or spirit, which always maintains the same temperature as the surrounding medium, and accommodates itself to these changes by altering its own density in the same proportion. The living animal, on the contrary, as always maintaining a temperature of its own, and as constantly resisting cooling agencies, is not to be considered as passively submitting, like the fluid of the thermometer in its ordinary state. When heated to ninety degrees Fahrenheit, that being nearly the temperature of the surface of our bodies — in the rapidity with which it is cooled, depending on the intensity of the cooling influences, it furnishes an index to their combined effect. It does not depict the force of any one of the cooling influences taken singly, but gives the sum of them all acting simultaneously." The facts illustrated by the heated thermometer are at least six in number, according to the experiments hitherto performed by Dr. Osborne. It shows the conducting power of air and water; the cooling effects of currents of air and water; the effect of wind in cooling the body and all other objects of a higher temperature than itself; the refrigerating effect of air admitted into apartments; the degree of heat derived from fires in rooms as compared with the cooling effect of currents rushing towards the fire; and the cold and heat of climates as actually felt by human beings. It is evident that a heated thermometer is capable of many useful applications.

New Barometer. — Barometers, of the size of a Geneva watch, and weighing but two and a quarter ounces, have recently been introduced. Their accuracy is guaranteed to be fully equal to other instruments in general use, and the price is £4 10s.

THE PROBABLE CAUSE OF THOSE EXPLOSIONS OF STEAM-BOILERS CALLED FULMINATING.

The following is the substance of a paper on the above subject recently presented to the French Academy of Sciences by M. Mangin: — It results from the admirable experiments of M. Dufour, that the temperature of water may, under certain circumstances, be brought to 178° Cent. (352.5° Fah.) without the production of boiling. These circumstances are the insulation from contact with the vessel, and insulation from contact with the air. Ebullition is produced by contact with a solid, that is, by the disturbance of the molecular equilibrium, and there is then a sudden evolution of steam. Nevertheless, every solid contact is not equally efficient in producing this change of state, and it results from the experiments of M. Dufour that isolation from contact with the vessel is not absolutely necessary for the production of the phenomenon. What appears to be indispensable is that the water shall be deprived of air, that the operation shall be carried on slowly, and that the heated mass shall be withdrawn from external disturbing causes. Having explained these preliminaries, let us see how the explosions called *fulminating* are to be explained.

These explosions take place only when the machine has been for a greater or less time at rest, and generally at the moment when they are about to resume the movement of the machine, and the boiler by its complete quietness gives no indication of the event. It is enough to open the throttle-valve, or one of the gauge-cocks, or the door of the furnace or ash-pit, or, in fact, any disturbance of the unstable equilibrium which has been established, to decide the catastrophe. It has also been remarked that, before the explosion, the pressure in the boiler is rather low than high. What, then, has taken place?

When the machine was stopped, the pumps were also stopped; the furnace and ash-pit doors were closed, as were all the escapes for steam or water. The ebullition continued, the safety-valve acted, and the water which had recently been pumped in was purged from air. Then, when the activity of the fire had fallen sufficiently, the valve fell into its seat, and the apparatus assumed a state of repose. If the atmosphere was calm, the draft null, and the escapes of water and steam hermetically closed, the apparatus (allow me to use the figure) has gone to sleep, and the molecules of water being at rest, the temperature has gradually been raised to a point notably above that of evaporation under the existing pressure. As the water produces no steam, that pressure may be and may keep below that necessary for the action of the safety-valve. Things being in this condition, let any cause whatever disturb the equilibrium of the molecules, and all the heat stored up in the liquid mass is instantly employed in producing an enormous volume of steam, while the mass of water not evaporated falls to the temperature corresponding to its pressure.

Figures will easily account for the violence of the explosion which takes place. Let us suppose, in fact, that the pressure in the boiler, before the explosion, was four atmospheres, and that the temperature, in the quiescent state of the water, was only 170° Cent. (338° Fah.) As at four atmospheres the temperature of the water and steam is 145° Cent. (293° Fah.), each kilogramme of water in the boiler contains 25 units of heat above its normal quantity. Therefore, the moment this heat was liberated, it must have converted into steam

$$\frac{25}{606.5+0.305\times145-145},$$

or nearly $\frac{1}{20}$th of a kilogramme of water; that is, about one-twentieth of the mass of water in the boiler was suddenly converted into steam.

Now, if we suppose that the volume of water in the boiler was double that of the steam, a quantity of water equal to one-tenth of the volume of the steam is suddenly vaporized; and as, at a pressure of four atmospheres, one volume of water produces four hundred and seventy-seven volumes of steam, the volume of the steam will be increased forty-seven times, and the pressure will be one hundred and eighty-eight atmospheres. It will be conceived that against such generations of steam the safety-valves are of no effect, and that the explosions are really fulminating.

This manner of looking at the phenomenon leads to the suggestion of the following precautions: to prevent the *torpor* of the water, let the boiler be so arranged that there shall be a constant circulation kept up by the difference of temperatures of different parts. A second precaution easily taken is never to close a boiler when at rest, hermetically, but to keep the safety-valve slightly raised, or a steam-cock a little open, so that a small quantity of steam may always be forming.

RADIATION AND ABSORPTION.

The following note, addressed to Sir John Herschel by Professor Tyndall, is published in the *London Mechanics' Magazine:* — I have been for some time experimenting on the permeability of our atmosphere to radiant heat, and have arrived at the conclusion that true air, that is to say, the mixture of oxygen and nitrogen which forms the body of our atmosphere, is, as regards the transmission of radiant heat, a practical vacuum. The results from which the opacity of air has been inferred are all to be ascribed to the extraneous matters diffused in the atmosphere, and mainly to the aqueous vapor. The negative results recently obtained by that eminent experimenter, Professor Magnus, of Berlin, have induced me to re-investigate this point; and the experiments which I have made not only establish the action of aqueous vapor, but prove this action to be comparatively enormous. Here is a typical case: — On the 10th of this month, I found the absorptive action of the common air of our laboratory to be made up of three components, the first of which, due to the pure air, was represented in magnitude by the number one; the second, due to the transparent aqueous vapor, was represented by the number forty; while the third, due to the effluvia of the locality and the carbonic acid of the air, was represented by the number twenty-seven. The total action of its foreign constituents on the day in question was certainly sixty-seven times that of the atmosphere itself; while the aqueous vapor alone exerted an action at least forty times that of the air.

I have also to communicate to you some results of lunar radiation which connect themselves with your speculations. On the 18th of October, 1861, I made a series of observations on the moon, from the roof of the Royal Institution. From six concurrent experiments, I was compelled to infer that my thermo-electric pile lost more heat when presented to the moon than when turned to any other portion of the heavens of the same altitude. The effect was equivalent to a radiation of *cold* from our satellite. I was quite unprepared for this result, which, however, you will at once perceive may be an immediate consequence of the moon's *heat.* On the evening in question, a faint halo which surrounded the moon, and which was only visible when sought for, showed that a small quantity of precipitated vapor was afloat in the atmosphere. Such precipitated particles, in virtue of their multitudinous reflections, constitute a powerful screen to intercept the terrestrial rays, and any agency that removes them and establishes the optical continuity of the atmosphere must assist the transmission of terrestrial heat.[1] I think it may be affirmed that no

[1] I was going to add "into space," but the expression might lead to misapprehension. My experiments indicate that the absorption of water is a *molecular* phenomenon. If we suppose the aqueous vapor of the atmosphere to be con-

sensible quantity of the obscure heat of the moon, which, when she is full, probably constitutes a large proportion of the total heat emitted in the direction of the earth, reaches us. This heat is entirely absorbed in our atmosphere; and on the evening in question it was in part applied to evaporate the precipitated particles, hence to augment the transparency of the air round the moon, and thus to open a door in that direction for the escape of heat from the face of my pile. The instrument, I may remark, was furnished with a conical reflector, the angular area of which was very many times that of the moon itself.

In a paper recently communicated to the Royal Society, Professor Tyndall has detailed the results of some additional investigations on the absorption of heat by gases and vapors. The absorption of radiant heat by atmospheric air in a short tube, and at a tension of thirty inches, being taken as 1; chlorine would be 36; hydrochloric acid, 62; carbonic acid, 90; sulphuretted hydrogen, 390; olefiant gas, 970; ammonia, 1,195. The absorption of radiant heat by vapors was also found to be very considerable, and even small quantities of perfumes, when diffused through common air, increase its power of arresting heat to an extraordinary degree: thus the absorptive power of air charged with the perfume of patchouli is thirty times greater than that of pure air; lavender increases the power to sixty times, and aniseed three hundred and seventy-two times the natural amount; hence the perfume arising from a bed of flowers increases the temperature of the air around them by rendering it more absorptive of radiant solar heat. The vapor of water, when present, increases the absorption of heat by the air in a very extraordinary degree. Dr. Tyndall infers that as the amount of vapor diminishes rapidly at a distance from the earth's surface, the sun's rays are not sensibly arrested until they reach our atmosphere, but that, on the other hand, the heat of the earth is prevented from being radiated into the free space and lost, by the existence of vapor in the air; and owing to the influence of this action, he thinks that even those planets most distant from the sun may have a temperature sufficiently high to render them inhabitable.

Radiation of Heat at Night. — About the period of sunset, provided the sky be clear, the temperature of the air in contact with the earth's surface is cooler than that of the atmosphere at a certain height above the ground. This is attributable to the gradual cooling of the earth's surface, arising from the nocturnal radiation of the heat into empty space. The cooling of the surface of the earth naturally gives rise to a corresponding diminution of the temperature of the stratum of air in its immediate vicinity; the effect is communicated to the stratum above, though naturally in a less degree, and so on from one stratum to another, until a height be attained at which the temperature of the atmosphere is found to be equal to that of the stratum of air in contact with the earth. Prof. Marcet

densed to a liquid shell enveloping the earth, the experiments of Melloni would lead us to conclude that such a shell would completely intercept the obscure terrestrial rays. And if the vapor be equally energetic, our atmosphere would prevent the *direct* transmission of the obscure heat of the earth into space. On this point, however, I wish to make some further observations.

in October last made a series of observations on the Lake of Geneva to ascertain whether the effects of nocturnal radiation, tending to produce a gradual increase of temperature on ascending above the earth's surface, are entirely dependent on the radiation of the ground, properly so called, or whether they are equally perceptible above a large sheet of water.

With mercurial thermometers capable of showing a tenth part of a degree (Centigrade), the temperature of the air at three inches, six feet, and fifteen feet above the surface of the lake was examined, the observations being made at the distance of about six hundred yards from the land during exceptionally fine weather. Comparative observations were made at the same moment on the borders of the lake within a few feet of the water, and in the centre of a large field about seven hundred yards from the lake. The average results of these observations are given in the following table, the temperature being expressed in Centigrade degrees: —

	Lake.	Shore.	Field.
Surface	12.°	9.90°	6.98°
Three inches	11.65	10.40	8.
Six feet	11.62	10.55	9.10
Fifteen feet	11.80	10.62	9.65

From these observations Marcet draws the following conclusions: 1. The gradual increase of temperature occurring on ascending through the lower strata of the atmosphere, which appears constantly to prevail on land about and after sunset, is not apparent above a large surface of water. 2. The immediate vicinity of a large sheet of water is sufficient to modify to a considerable extent the effects of the nocturnal radiation of the earth, and thereby materially diminish the increase of temperature observed under ordinary circumstances on ascending above the surface of the ground. 3. A striking difference (amounting to between two and three Centigrade degrees) is constantly observed between the temperature of the atmosphere a few feet above the ground, and that of the air at the same height above a large sheet of water.

SPECIFIC HEAT AND CHEMICAL COMBINATION.

At a late meeting of the London Chemical Society, a paper was communicated by Mr. J. Croll, on the above subject, of which the following is the substance: —

After alluding to the opinion generally held with reference to the specific heat of compounds, compared with that of their component elements, namely, that a diminution took place during combination unless the resulting compound was a fluid, in which case the specific heat was increased, he stated that he had found this was not correct; for that the specific heat of compound gases and liquids was generally less, and that of solids more, than that of their component elements. A table of the specific heat of different bodies had been drawn up, from which it appeared that out of ninety-four solid compounds, the specific heat of sixty-six had been increased, and of twenty-eight diminished, by combination; out of twenty-eight gases there was an increase with six, and a decrease with twenty-two;

while out of thirty-three liquids there was an increase in twelve, and a decrease in twenty-one cases. In fourteen cases the specific heat increased during the passage of the substance from the gaseous to the liquid state, and it was reduced in eleven cases while changing from liquid to solid. From this it was probable that the increase in the specific heat of a compound solid body above that of its elements did not depend simply on its being solid, but, on the contrary, that it was solid because its specific heat exceeded that of its elements. The following considerations would perhaps throw some light on the subject: When any substance is heated, part of the heat is expended in producing expansion, and the other part in raising the temperature, and the sum of these two is equal to the specific heat. If a gas, confined under a constant pressure, is heated, it will be found to have a greater specific heat than if its volume be constant, the reason being that in the former case some of the heat is absorbed in producing expansion; for the heat cannot do two things at the same time, and that which produces the expansion cannot affect the thermometer. When heat is applied to a mass of ice, the temperature rises to thirty-two degrees, and then becomes stationary; this is the result of the difference in resistance that the heat experiences at the two outlets, the greatest amount passing to that at which there is least resistance. Hence the molecular force of a solid body must diminish as the temperature rises; at thirty-two degrees the molecular force of ice cannot overcome the repulsive force. On heating a gas, there is no loss from molecular influences, but with a solid, part of the heat is taken up in producing molecular changes, and, therefore, the less heat a solid contains, the more does it resemble a gas in this respect, the specific heat increasing with the rise of temperature; from which it follows that the higher the melting point of a solid the less is the specific heat, which is experimentally found to be the case. In those cases of combination in which a change in one of the elements from a solid to a fluid state, or the contrary, took place, a change in the specific heat of the resulting compound could be accounted for. On the whole, it would appear that the changes in the specific heat of bodies that occurred during combination were due not only to chemical action, but also to molecular changes; the real specific heat of an atom remaining probably the same under all conditions.

IMPROVEMENT IN THE OXYHYDROGEN LIGHT.

At a recent meeting of the Manchester Philosophical Society, Mr. Alfred Fryer stated that he had recently been making a series of experiments with the oxyhydrogen light, with a view to determine what substance made incandescent produced the greatest amount of light. He operated on various salts of calcium, magnesium, strontium, barium, and also upon some other substances. The best results were obtained from magnesium. The sulphate of magnesia, when baked, yielded a bright light, but was decomposed by the heat; and the sulphurous acid escaping was very unpleasant. Calcined magnesia succeeded the best of all; but when the powder was used, the gases blew it away. When the powder was mixed with water, and afterward dried, the cake was friable; and when the dry powder was pressed into a mould by means of hydraulic pressure, the cake split up into laminæ when subjected to the gases. After many experiments with the materials in different proportions, it was found that sulphate of lime one part, and calcined magnesia two parts, mixed with water and moulded into a cake and dried, produced the best results. This, however, is not all that could be desired, as in time the cake becomes cracked and fissured by the gas. The illuminating power is to that of lime, pressure and volume of gas being equal, as fifty-four is to twenty-seven.

BURNING GUNPOWDER IN VACUO.

M. Bianchi, of Paris, has recently exhibited before the French Academy some curious experiments on the combustion of gunpowder in a vacuum. He found that this substance, and also the fulminates, burnt quickly if loose in an exhausted vessel, and suddenly brought to a temperature exceeding 2,000°. If, however, the powder was placed, under similar circumstances, in a pistol, it inflamed with the suddenness exhibited in the air. Gun-cotton slowly disappeared, the layer nearest the source of heat going first, but without the production of any light. In all these cases the products of combustion were the same as in air. Combustion also took place in nitrogen, carbonic acid, and other gases which do not support it, and there was little diminution of the ordinary rapidity of the process.

EFFECTS OF FROST ON IRON.

Mr. David Kirkaldy, of Glasgow, in a recently published work detailing his experiments in testing the strength of iron and steel, also describes some experiments to test the effects of frost upon metal. A bar of Glasgow best bar iron, of three-fourths of an inch diameter, was forged into ten bolts, and six of them were exposed all night to intense frost in the month of December, 1860, then tested next morning, when the thermometer stood at twenty-three degrees Fah. The other four bolts were kept warm all night, and protected during testing. Three of the ten bolts were tested with gradual, and seven of them with sudden strains. With gradual strains the bolts exposed to frost gave way with 54,385 pounds strain; the unfrozen bolts stood a strain of 55,717 pounds, — a difference of 2.3 per cent. in favor of the latter. When submitted to sudden strains, the difference was 3.6 per cent. in favor of the unfrozen bolts.

MEASURING DISTANCES BY THE TELESCOPE.

At a recent meeting of the London Institution of Civil Engineers, Mr. W. Bray gave the following description of an arrangement for measuring distances by the telescope: — He found that it was convenient to have two distinct hairs on the diaphragm of the level — one about three-twentieths of an inch above the level hair, and the other as much below, so as to read one foot on the staff at one chain, and ten feet at ten chains. Since, however, in focusing the instrument to any object it was necessary to bring the cross hairs into such new focus, which was proportionally further from the object-glass as the object was nearer, the angle which the hairs subtended from the centre of the object-glass must be variable, diminishing as the distance was diminished. Hence a correction was necessary, and this the theory of refraction by lenses furnished. It showed that the error was constant at all distances, amounting in every case to the focal length of the object-glass for parallel rays. This constant was to be added in reading the staff, by bringing the lower cross hair near any even division of feet, but exactly two-hundredths of a foot above it, corresponding with the two links from the centre of the instrument to the anterior focus, in the cases of a five-inch theodolite and ten-inch level. Then, by reading the upper distance hair, and deducting the even number of feet at the lower hair, the difference was the distance in chains and links. If the compass was sufficiently delicate, any operation of contouring, or running trial levels, could be performed with rapidity and accuracy. When provided with the two distance hairs, the level of the ground could be taken above and below the ordinary range of the instrument. The use of these distance hairs for eighteen years had proved their practical value. In taking the widths of rivers or deep ravines, distances of twenty chains had been read in favorable weather; and when the hairs were accurately fixed on the diaphragm, they might be used for even fractions of a link, in taking widths incapable of direct measurement.

When applied to a theodolite, they could be used for measuring distances on sloping ground. But in that case, since the line of sight was no longer perpendicular to the staff, a correction was necessary, for which a table was given, showing the angles of elevation of the various heights, which were simple fractional parts of the horizontal distance. When the horizontal distance to the staff had been ascertained, the theodolite was to be elevated to the tabular angle corresponding to the fractional rise nearest to the slope of the ground; then that fraction of the horizontal distance, less the reading of the staff, would be the correct rise. With the theodolite, it was convenient to have another set of hairs, for reading the distance in feet, as well as in links. In clear weather, with a distinct reading staff, a distance of forty chains had been read between the foot and link hairs.

DEW-BOW SEEN ON THE SURFACE OF MUD.

Professor Rankine, in a letter to the London *Philosophical Magazine*, says: — There was seen to-day (February 13, 1862), by myself and some other persons in this neighborhood, a very beautiful phenomenon, of which the cause is obvious, and of such a nature that one would expect the phenomenon to occur frequently; but I do not remember to have yet seen any instance of it recorded in any scientific publication. I refer to a prismatically-colored hyperbolic iris, or bow of the first order, exactly resembling that sometimes seen on a field of dewy grass; but in this case it was displayed on the muddy surface of a by-road, and on the less trodden parts of an adjoining turnpike road, throughout a distance of more than a mile. The time was between half-past twelve and one P. M.; the morning had been hazy, but the mist had cleared away, and the sun was shining brightly.

The angular dimensions of the iris were obviously the same with those of a rainbow of the first order; its colors were complete, from red to violet, and very bright and distinct, especially where the mud was softest and moistest; where a sheet of water, how thin soever, covered the mud, the iris vanished. No trace of an iris could be seen on the grass, in the sky, or anywhere but on the mud; and on those parts of the turnpike road where the mud had been much disturbed no iris was visible.

The necessary conclusion from this appearance is, that the surface of the mud must have been thickly covered with globules of pure water, perfectly spherical, and not in absolute contact with the mud, although resting on it; but those globules must have been extremely minute, for they were invisible to the closest inspection with the naked eye.

THE SUPERNUMERARY BOWS IN THE RAINBOW.

In a communication on the above subject to the British Association, in 1862, by the Rev. J. Dingle, the author stated that he had investigated a method of approximating to the size of the drops of rain corresponding to any given position of the supernumerary bows produced by the interference of the two luminiferous surfaces proceeding from each drop. It appeared from his tables appended to the paper that the size which Dr. Young (without giving his method of calculation) had assigned to the drops under certain conditions was within $\frac{1}{2000}$th of an inch of the truth, and was more accurate than that assigned subsequently by Mr. Potter, whose method was not quite satisfactory. The subject was interesting as illustrating the marvellous accuracy with which the operations of nature are carried out, and the delicate adaptation of our organs for discerning them.

THE RELATIVE AMOUNT OF SUNSHINE FALLING ON THE TORRID ZONE OF THE EARTH.

At the British Association, 1862, Prof. Hennesey stated that he had ascertained that the amount of sunshine falling on the outer limits of the earth's atmosphere between the tropics is very nearly equal to that which falls on the remaining portions of the earth's surface. If we reflect that, according to Forbes's researches, the amount of heat extinguished by the atmosphere before a given solar ray reaches the earth, is more than one-half for inclinations less than 25°, and that for inclinations of 5° only the twentieth part of the heat reaches the ground, we immediately see that the torrid zone of the earth must be far more effective than all the rest of the earth's surface as a recipient of solar heat. It follows, therefore, that the distribution of the absorbing and radiating surfaces within the torrid zone must, upon the whole, exercise a predominating influence in modifying general terrestrial climate.

VELOCITY OF LIGHT.

M. Foucault, to whom we owe the physical demonstration of the earth's movement, has announced a discovery respecting the velocity of light and the sun's parallax, which promises important results. By means of a newly-devised instrument he has ascertained that the velocity of light is notably less than has been supposed. Instead of a velocity of 308,000,000 of metres in a second, he estimates it as 298,000,000. If this be correct, the sun's parallax is 8.86″, instead of 8.57″. *Thus the mean distance of the sun from our earth is diminished by about* $\frac{1}{30}$.

DISPERSION OF LIGHT.

M. Radan, writing to the Paris *Cosmos* upon the results of Cauchy, and citing his formulæ, observes: "It results from these formulæ that the velocity of a luminous ray depends, in general, upon its color; and that the unequal velocities of the different rays of the spectrum are the cause of their dispersion by the prism."

THE FORMATION OF HALOS.

Sir John Herschel has devised an elegant mode of illustrating the action of minute refracting spheres. He mounts the spores of the common puff-ball in a film of oil between two pieces of glass. When these are held close to the eye, and a candle viewed through them, beautiful concentric halos appear.

NEW OPTICAL EXPERIMENT.

Mr. Slack calls attention to concentric circles of light, exquisitely marked by fine black, intersecting lines, which may be seen by taking a stout glass tube, about one-eighth of an inch in diameter and six or eight inches long, holding it horizontally opposite the flame of a candle, and looking at the light through it. A piece of paper rolled round the tube shuts out all unnecessary illumination, and makes the phenomenon more clear.

IMPROVEMENT IN THE KALEIDOSCOPE.

The following note addressed to the London *Literary Gazette*, by Mr. J. A. Davis, suggests an improvement in the kaleidoscope, or, in fact, in any instrument where combinations of colors are produced by rotation: — "Sir: If the pieces of glass used in a kaleidoscope were cut in various regular forms, the effect of the instrument would greatly be improved, and this by means of the duplication of symmetry or evenness, which can readily be understood by all who have a competent knowledge of it. Every apparatus or instrument for producing color by rotation of colored surfaces would be improved if a conical glass vessel, the upper external part of which is silvered, were fixed upon the spindle with its apex downwards, in which a number of pieces of various colored glass were placed, and underneath it a mirror at a proper angle were fixed. Upon the middle being rotated, the pieces of glass would, by centrifugal force, be carried towards, and in some cases against, the internal parts of the cone, and be illuminated by the mirror beneath, and reflected by the silvered parts of the vessel. The effect produced would be a very beautiful one, a number of concentric colored rings being visible, the color, size, and arrangement of which would in every case be different, the phenomena obtained being infinitely variable. Another improvement would be made if the colored discs were bent upwards, and, when in motion, looked at across or horizontally, the eyes being at their level, the blackened disc being removed, in which cases the colored bands are arranged in vertical rows."

MICROSCOPIC WRITING.

At the London International Exhibition, 1862, a machine for the execution of microscopic writing was exhibited by a Mr. Peters, which has enabled the Lord's Prayer to be written in the 356,000th of a square inch — a space like a minute dot. The English Bible contains 3,566,480 letters; the Lord's Prayer, ending with "deliver us from evil," 223 letters; so that the Bible is 15,992 times longer than the prayer, and if we employ round numbers we may say it could be written in 16,000 times the space occupied by the prayer, or in less than the twenty-second part of a square inch. In other words, the whole Bible might be written twenty-two times in one square inch! This wonderfully minute writing is clearly legible when placed under a good microscope. In using the machine the operator writes with a pencil attached to one end of a long lever; whatever marks he makes on a piece of paper are infinitesimally reduced in corresponding motions, by which a glass plate is moved over a minute diamond point. By means of a geometric chuck, beautiful geometric designs may be engraved on a similar scale of minuteness.

The true value of the instrument, however, is shown in its application to the purposes of microscopic science; it is capable of producing Nobert's microscopic tests in bands of lines numbering 100,000 to the inch, and micrometers with divisions rising to the one 4000th of an inch, which, when crossed, produce perfectly distinct and sharp angled squares, each one sixteen millionth of an inch in size ($4000 \times 4000 = 16,000,000$).

NEW VIEWS RESPECTING THE ORIGIN OF LIGHT.

Mr. C. E. Townsend, of Locust Valley, N. Y., has propounded the following theory respecting the origin and development of solar light and heat. He says: —

Matter in space is reduced to a minimum, so that solar light and heat can exert no appreciable effect, either by absorption or radiation; hence solar light and heat can only be developed into such on reaching the atmosphere or body of a planet, and therefore all lights seen in the heavens, whether from the sun, moon, planets, stars, nebulæ, comets, or erratic bodies, as meteors, are developed only as light on reaching our atmosphere. In consequence, we look in vain through space for light darting off to other planets from the sun, or from one to the other. On the supposition that light and heat are convertible into electricity, the Leyden jar, charged with electricity, is analogous to the sun, also so charged, and not until a conducting body is brought within the required distance of the former does the electricity develop itself, in the form of light and heat, upon or near the conducting body.

If absolute light existed in the sun, and as such were transmitted through space to the planets, then all space would necessarily be radiant with light, and, as a consequence, we should have no night. Whereas, our nocturnal heavens do not disclose one single ray in its passage to the planets, notwithstanding which they glow with the light constantly received from the sun ; which is, necessarily, proof that solar light is not developed until it reaches the planet, and that, consequently, the material of light, in its passage through space from the sun to the planets, being invisible, cannot be developed into light.

LUMINOSITY OF PHOSPHORUS.

The following paper was read before the British Association, 1862, by Dr. Moffat : —

If a piece of phosphorus be put under a bell-glass and observed from time to time, it will be found at times luminous, and at others non-luminous. When it is luminous, a stream of vapor rises from it, which sometimes terminates in an inverted cone of rings similar to those given off by phosphuretted hydrogen ; and at others it forms a beautiful curve, with a descending tint equal in length to the ascending one. The vapor is attracted by a magnet ; it is also attracted by heat, but it is repelled by cold. It renders steel needles magnetic, and it is perceived only when the phosphorus is luminous. Results deduced from daily observations of the phosphorus in connection with the readings of the barometer, the temperature and degree of humidity of the air, with directions of the wind, for a period of eighteen months, show that periods of luminosity of phosphorus and non-luminosity occur under opposite conditions of the atmosphere, — the former being peculiar to the equatorial, while the latter is peculiar to the polar current. By the catalytic action of phosphorus on atmospheric air, a gaseous body (superoxide of hydrogen) is formed, which is analogous to, if not the same as, atmospheric ozone, and it can be detected by the same tests. The author has found, by his usual tests, that *phosphoric* ozone is developed only when the phosphorus is luminous. Periods of luminosity and periods of atmospheric ozone take place under similar atmospheric conditions, and the conditions of non-luminous periods and periods of non-atmospheric ozone are the same. From the author's observations in connection with this matter, which extend over several years, it appears that ninety-nine per cent. of luminous periods and ninety-one per cent. of ozone periods commence with decreasing readings of the barometer and other conditions of the equatorial current ; and that ninety-four per cent. and sixty-six per cent. terminate with increasing readings and the conditions of the polar current. Luminous periods commence and luminosity increases in brilliancy on the approach of storms and gales, and ozone periods commence and it increases in quantity under similar conditions. There is, it would appear, also, from these observations, an intimate connection between the approach of storms, the commencement of luminous and ozone periods, and disorders of the nervous, muscular and vascular systems. Here the author gave the dates of many storms and gales, and the occurrence of diseases of the above class, showing their coincidence ; and in corroboration of what he had stated, he mentioned the fact that there was a concurrence in the issuing of Admiral FitzRoy's cautionary telegrams and these diseases. He also stated that he views the part performed by ozone in the atmosphere as being similar to that performed by protein in the blood; the latter giving oxygen for the disorganization of worn-out tissues in the animal economy, the former giving oxygen to the products of decomposition and putrefaction, and rendering them innocuous or salutary compounds. With these views, he has used phosphorus as a disinfectant; and, from the results he has obtained, he believes that by using ozone artificially formed by the action of phosphorus in localities tainted with the products of putrefaction, just in sufficient quantity to tinge the usual test-paper, all diseases of the pythogenic class would be prevented. Although the data are too few to theorize upon, Dr. Moffat hoped that he would be excused for pushing the matter beyond a simple statement of facts and observations, as many facts had been observed in nature which strongly corroborated all he had advanced. Ozone, he observed, is in all probability formed wherever there is phosphorescence; and this is by no means an uncommon phenomenon. It is seen in life and in death, in the animal and vegetable kingdoms, and in the mineral kingdom. Here many instances of phosphorescent bodies were enumerated, among which the night-shining Neries was named as becoming particularly brilliant with a direction of wind from points of the compass between east and south; and the fact that the sea becomes luminous on the approach of storms by marine animals floating on its surface was noticed. Many phosphorescent minerals were named; the fluor spar being particularly pointed out as being not only phosphorescent on slight increase of temperature, but as giving off ozone. The author concluded by observing that it is not improbable that atmospheric ozone is formed by the phosphorescence of these and similar bodies, and pointed to the absence of ozone and weak magnetic action during cholera periods, which are periods of non-luminosity, and to the disappearance of cholera with the setting in of the equatorial current, which is ozoniferous and favorable to luminosity. The aurora, the author thinks, may yet be proved to be a display of luminosity.

RESEARCHES ON THE SOLAR SPECTRUM.

During the past year, Mr. Kirchhoff has published a complete account of his researches on the "Solar Spectrum and the Spectra of the Chemical Elements," and the same has been translated into English and published in London by Professor Roscoe of Owen's College, Manchester. In the *Annual of Scientific Discovery* for 1862, pp. 133–143, we gave a full *resumé* of the principal points of interest which had then been made public respecting this new department of scientific research. In the present article, we propose again briefly to review the subject, and indicate the additions made to our knowledge during the past year.

Although the constitution of solar light was first demonstrated by Newton, in 1675, the existence of the marked peculiarity of dark lines on the spectrum remained unknown until 1802, when Dr. Wollaston noticed that when he allowed the sunlight to fall through a narrow slit upon the prism, a number of dark lines, cutting up the colored portions of the spectrum, made their appearance. These dark lines, or spaces, of which Wollaston counted only seven, indicate the absence of certain distinct kinds of rays in the sunlight; they are, as it were, shadows on the bright background.

It is, however, to the celebrated German optician Fraunhofer that we owe the first accurate examination of these singular lines. By a great improvement in the optical arrangements employed, Fraunhofer, rediscovering these lines, was able to detect a far larger number of them in the solar spectrum than had been observed by Wollaston. He counted no less than five hundred and ninety of these dark lines, stretching, throughout the length of the spectrum, from red to violet, and in the year 1815 drew a very beautiful map of them, some of the most important of which he designated by the letters of the alphabet. Fraunhofer carefully measured the relative distances between these lines, and found that they did not vary in sunlight examined at different times. He also saw these same dark fixed lines in reflected as well as in direct solar light; for on looking at the spectrum of moonlight and of Venus-light the same lines appeared quite unaltered in position. But he found that the light of the fixed stars was not of the same kind as direct or reflected sunlight, as the spectra of the starlight contained dark lines entirely different from those which are invariably seen in the solar spectrum. From these observations Fraunhofer, so early as 1815, drew the important conclusion that these lines, let them be what they may, must in some way or other have their origin in the sun. The explanation of the production of these lines was reserved for a subsequent time; but Fraunhofer opened the inquiry, and all his conclusions have been borne out by recent and more elaborate investigations.

Since the time of Fraunhofer our knowledge of the constitution of the solar spectrum has largely increased. Professor Stokes, in his beautiful researches on fluorescence, has shown that similar dark lines exist in that part of the spectrum extending beyond the violet, which require special arrangements to become visible to our eyes; and Sir David Brewster and Dr. Gladstone have mapped with great care about two thousand lines in the portion of the spectrum from red to violet.

But it is to Kirchhoff, the Professor of Physics in the University of Heidelberg, that we are indebted for by far the best and most accurate observations of these phenomena. In place of using one prism, as Fraunhofer did, Kirchhoff employed four prisms of most perfect workmanship, and thus enjoyed the advantage of a far greater dispersion, or spreading out, of the different rays than the Munich optician had obtained. The lines were observed through a telescope having a magnifying power of forty, and when the whole apparatus was adjusted with all the accuracy and delicacy which the perfection of optical instruments now renders possible, Kirchhoff saw the solar spectrum with a degree of minute distinctness such as had never before been attained; and of the beauty and magnificence of the sight thus presented those only who have been eye-witnesses can form any idea.

Kirchhoff's purpose was not merely to observe the fine vertical dark lines which in untold numbers crossed the colored spectrum, stretching from right to left; he wished to measure their relative distances, and thus to map them, exactly as the astronomer determines the position of the stars in the heavens, and the surveyor triangulates and marks out the main features of a country, so that future wanderers in this new field may find fixed and well-recognized points from which to commence their own excursions. Professor Kirchhoff is far from thinking that his measurements, delicate and numerous though they be, have exhausted the subject. The further we penetrate into the secrets of nature, the more we find there remains to be learned. He saw whole series of nebulous bands and dark lines which the power of his instrument did not enable him to resolve; and he thinks that a larger number of prisms must be employed to effect this end. He adds: "The resolution of these nebulous bands appears to me to possess an interest similar to that of the resolution of the celestial nebulæ, and the investigation of the spectrum to be of no less importance than the examination of the heavens themselves." True, indeed, does this appear, when we learn that it is by the examination of these lines that we can alone obtain the clue to the chemical composition of sun and stars!

The exact measurement of the distances between the lines was made by moving the cross-wires of the telescope from line to line by means of a micrometer screw with a finely divided head, and reading off the numbers of divisions through which the screw had to be turned. The breadth and degree of darkness were also noticed, and thus the lines were mapped. In order to give a representation in the drawing of the great variety of the shade and thickness of the lines, they were arranged according to their degree of blackness, and drawn of six different thicknesses. First, the darkest lines were drawn with thick, black Indian ink; the ink was then diluted to a certain extent, and the lines of the next shade drawn, and so on to the lightest series. As soon as a portion of the spectrum had been drawn in this manner, it was compared with the actual spectrum, and the mistakes in the breadth and darkness of the lines, as well as in their position, corrected by fresh estimations, and the drawing made anew. A second comparison and another drawing were then made, and this process repeated until all the groups of lines appeared to be truthfully represented. In the English edition of Kirchhoff's Memoir, above referred to, lithographic representations of the appearance of the spectrum through Kirchhoff's instrument are given, presented in six different colored tints.

In the *Annual of Scientific Discovery* for 1862, it was shown how an examination of these dark lines of the solar spectrum had revealed somewhat of the chemical constitution of the solar atmosphere, and also how the existence and development of the lines had been applied for the chemical analysis of terrestrial matter. In regard to the latter point it is unnecessary to say more than that Mr. Kirchhoff announces in his Memoir that he has carried spectrum analysis to such perfection that he has without difficulty been able to distinguish the presence of minute traces of the rare metals erbium and terbium, as well as cerium, lanthanum, and didymium, when they are mixed together; a feat which the most experienced analyst would find it almost impossible, even after the most lengthened and careful investigation, to accomplish with the older methods.

In endeavoring, says a writer in the *Edinburgh Review*, to form an idea of the present and future bearings of the science of spectrum analysis as applied to the investigation of terrestrial matter, we must remember that the whole subject is as yet in its earliest infancy; that the methods of research are scarcely known; and that speculations as to the results which further experiments will bring forth, are, therefore, for the most part, idle and premature. We may, however, express our opinion that a more intimate knowledge of the nature of the so-called elements, if it is to be attained at all, is to be sought for in the relations which the spectra of these substances present; and if a "transmutation" of these elementary bodies be effected, as is by no means impossible, it will be effected by help of the new science of spectrum analysis. That we shall thus gradually attain a far more accurate knowledge of the composition of the earth's crust than we now possess, is perfectly certain; nor is it less certain that, with the progress of the investigation, other new elementary bodies will be added to our already somewhat overgrown chemical family. We anticipate, moreover, important results to the art of medicine from the application of spectrum analysis to mineral waters, as they are termed, noted for their therapeutic qualities. The composition of these waters, their apparently inexhaustible faculty of reproduction, their modes of affecting the human frame in various states of health and disease, are only known as yet empirically. But it is altogether probable that the application of spectral analysis to the elements contained in these springs will bring them within the range of accurate medical knowledge, and perhaps extend the resources of medicine itself.

So long ago as 1815, Fraunhofer made the important observation, that the two bright yellow lines which we now know to be the sodium lines were coincident with, or possessed the same degree of refrangibility as two dark lines in the solar spectrum called by Fraunhofer the lines D. A similar coincidence was observed by Sir David Brewster, in 1842, between the bright red line of potassium and a dark line in the solar spectrum called Fraunhofer's A. The fact of the coincidence of these lines is easily rendered visible if the solar spectrum is allowed to fall into the upper half of the field of our telescope, whilst the sodium or potassium spectrum occupies the lower half. The bright lines produced by the metal, as fine as the finest spider's web, are then seen to be exact prolongations, as it were, of the corresponding dark solar lines.

Although the fact of the coincidence of several bright metallic lines with the dark solar lines was well known, yet the exact connection between the two phenomena was not understood until Prof. Kirchhoff investigated the subject. Nevertheless, before he gave the exact proof of their connection, some few bold minds had foreseen the conclusions to which these observations must lead, and had predicted the existence of sodium in the sun.

Wishing to test the accuracy of this frequently asserted coincidence of the bright metallic and dark solar lines with his very delicate instrument, Prof. Kirchhoff made the following very remarkable experiment, which is interesting as giving the key to the solution of the problem regarding the existence of sodium and other metals in the sun: — "In order to test in the most direct manner possible the frequently asserted fact of the coincidence of the sodium lines with the lines D, I obtained a tolerably bright solar spectrum, and brought a flame colored by sodium vapor in front of the slit. I then saw the dark lines D change into bright ones. The flame of a Bunsen's lamp threw the bright sodium lines upon the solar spectrum with unexpected brilliancy. In order to find out the extent to which the intensity of the solar spectrum could be increased without impairing the distinctness of the sodium lines, I allowed the full sunlight to shine through the sodium flame, and to my astonishment I saw that the dark lines D appeared with an extraordinary degree of clearness. I then exchanged the sunlight for the Drummond's or oxyhydrogen lime-light, which, like that of all incandescent solid or liquid bodies, gives a spectrum containing no dark lines. When this light was allowed to fall through a suitable flame colored by common salt, dark lines were seen in the spectrum in the position of the sodium lines. The same phenomenon was observed if instead of the incandescent lime a platinum wire was used, which being heated in a flame was brought to a temperature near its melting-point by passing an electric current through it. The phenomenon in question is easily explained upon the supposition that the sodium flame absorbs rays of the same degree of refrangibility as those it emits, whilst it is perfectly transparent for all other rays." — *Kirchhoff; Researches*, etc., pp. 13, 14.

Thus Kirchhoff succeeded in producing artificial sunlight, at least as far as the formation of one of Fraunhofer's lines is concerned. He proved that the yellow soda flame possesses this — at first sight anomalous — property of absorbing just that kind of light which it emits; it is opaque to the yellow D light, but transparent to all other kinds of light. Hence, if the yellow rays in the spectrum produced by the Drummond's light in the above experiment are more intense than those given off by the soda flame, we shall see in the yellow part of the spectrum shadows or dark lines; and if the difference of intensity be very great, these shadows may by contrast appear perfectly black. This opacity of heated sodium vapor for the particular kind of light which it is capable of giving off was strikingly exhibited by Prof. Roscoe, in a lecture on Spectrum Analysis, lately delivered by him in London at the Royal Institution. A glass tube, containing a small quantity of metallic sodium, was rendered vacuous and then closed. On heating the tube, the sodium rose in vapor, filling a portion of the empty space. Viewed by ordinary white light, this sodium vapor appeared perfectly colorless, but when seen by the yellow light of a soda flame, the vapor cast a deep shadow on a white screen, showing that it did not allow the yellow rays to pass through.

This remarkable property of luminous gases to absorb the same kind of light as they emit, is not without analogy in the cognate science of acoustics. Sound is produced by the vibration of the particles of gravitating matter, whilst light is supposed to be produced by a similar vibration of the particles of a non-gravitating matter, called the luminiferous ether. In the case of sound, a similar phenomenon to the one under consideration is well known. We are all acquainted with the principle of resonance; if we sound a given note in the neighborhood of a pianoforte, the string capable of giving out the vibrations producing that note takes up the vibrations of the voice, and we hear it answering the sound. The intenser vibrations proceeding in one direction are absorbed by the string, and emitted as waves of slighter intensity in every direction.

Not only did Prof. Kirchhoff show experimentally that luminous gases absorb the kind of light which they emit, by *reversing* the spectra of several of the metals, but by help of theoretical considerations he arrived at a very important general formula concerning the emission and absorption of rays of heat and light, which includes these phenomena as a particular case. The general law is called the *law of exchanges*, and it asserts that the relation between the amount of heat or of light which all bodies receive and emit is for a given temperature constant.

In order to determine and map the positions of the bright lines produced by the electric spectra of the various metals, Kirchhoff employed the dark lines in the solar spectrum as his guides. Much to his astonishment, he observed that dark solar lines occur in positions coincident with those of all the bright iron lines. Exactly as the sodium lines were identical in position with Fraunhofer's lines D, for each of the iron lines (and Kirchhoff examined more than sixty) a dark solar line was seen to correspond. Not only had each bright iron line its dark representative in the solar spectrum, but the breadth and degree of distinctness of the two sets of lines agreed in the most perfect manner, the brightest iron lines corresponding to the darkest solar lines. These coincidences cannot be the mere effect of chance; in other words, there must be some causal connection between these dark solar lines and the bright iron lines. That this agreement between them cannot be simply fortuitous is proved by Kirchhoff, who calculates — from the number of the observed coincidences, the distances between the several lines, and the degree of exactitude with which each coincidence can be determined — the fraction representing the chance or probability that such a series of coincidences should occur without the two sets of lines having any common cause; this fraction he finds to be less than 1-1,000,000,000,000,000,000, or, in other words, it is practically certain that these lines have a common cause.

"Hence this coincidence," says Kirchhoff, "must be produced by some cause, and a cause can be assigned which affords a perfect explanation of the phenomenon. The observed phenomenon may be explained by the supposition that the rays of light which form the solar spectrum have passed through the vapor of iron, and have thus suffered the absorption which the vapor of iron must exert. As this is the only assignable cause of this coincidence, the supposition appears to be a necessary one. These iron vapors might be contained either in the atmosphere of the sun or in that of the earth. But it is not easy to understand how our atmosphere can contain such a quantity of iron vapor as would produce the very distinct absorption lines which we see in the solar spectrum; and this supposition is rendered still less probable by the fact that these lines do not appreciably alter when the sun approaches the horizon. It does not, on the other hand, seem at all unlikely, owing to the high temperature which we must suppose the sun's atmosphere to possess, that such vapors should be present in it. Hence the observations of the solar spectrum appear to me to prove the presence of iron vapor in the solar atmosphere with as great a degree of certainty as we can attain in any question of natural science." — *Kirchhoff; Researches*, etc., p. 20.

This statement is not one jot more positive than the facts warrant. For to what does any evidence in natural science amount beyond the expression of a probability? A mineral sent to us from New Zealand is examined by our chemical tests, of which we apply a certain number, and we say these show us that the mineral contains iron, and no one doubts that our conclusion is correct. Have we, however, in this case proof positive that the body really is iron? May it not turn out to be a substance which in these respects resembles, but in other respects differs from, the body which we designate as iron? Surely. All we can say is, that in each of the many comparisons which we have made the properties of the two bodies prove identical; and it is solely this identity of the properties which we express when we call both of them iron. Exactly the same reasoning applies to the case of the existence of these metals in the sun. Of course the metals present there, causing these dark lines, *may* not be identical with those which we have on earth; but the evidence of their being the same is as strong and cogent as that which is brought to bear upon any other question of natural science, the truth of which is generally admitted.

We do not think we can give our readers a more clear and succinct account of the development of this great discovery than by quoting from Kirchhoff's admirable Memoir the following passage: —

"As soon as the presence of *one* terrestrial element in the solar atmosphere was thus determined, and thereby the existence of a large number of Fraunhofer's lines explained, it seemed reasonable to suppose that other terrestrial bodies occur there, and that, by exerting their absorptive power, they may cause the production of other Fraunhofer's lines. For it is very probable that elementary bodies which occur in large quantities on the earth, and are likewise distinguished by special bright lines in their spectra, will, like iron, be visible in the solar atmosphere. This is found to be the case with calcium, magnesium, and sodium. The number of bright lines in the spectrum of each of these metals is indeed small, but those lines, as well as the dark lines in the solar spectrum with which they coincide, are so uncommonly distinct that the coincidence can be observed with great accuracy. In addition to this, the circumstance that these lines occur in groups renders the observation of the coincidence of these spectra more exact than is the case with those composed of single lines. The lines produced by chromium, also, form a very characteristic group, which likewise coincides with a remarkable group of Fraunhofer's lines; hence I believe that I am justified in affirming the presence of chromium in the solar atmosphere. It appeared of great interest to determine whether the solar atmosphere

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contains nickel and cobalt, elements which invariably accompany iron in meteoric masses. The spectra of these metals, like that of iron, are distinguished by the large number of their lines. But the lines of nickel, and still more those of cobalt, are much less bright than the iron lines, and I was therefore unable to observe their position with the same degree of accuracy with which I determined the position of the iron lines. All the brighter lines of nickel appear to coincide with dark solar lines; the same was observed with respect to some of the cobalt lines, but was not seen to be the case with other equally bright lines of this metal. From my observations I consider that I am entitled to conclude that nickel is visible in the solar atmosphere; I do not, however, yet express an opinion as to the presence of cobalt. Barium, copper and zinc appear to be present in the solar atmosphere, but only in small quantities; the brightest of the lines of these metals correspond to distinct lines in the solar spectrum, but the weaker lines are not noticeable. The remaining metals which I have examined, viz., gold, silver, mercury, aluminum, cadmium, tin, lead, antimony, arsenic, strontium and lithium, are, according to my observations, not visible in the solar atmosphere." —*Kirchhoff; Researches*, etc., p. 21.

We are now in a position to understand why the discovery of the existence of these metals in the sun is no myth, no vague supposition, or possible contingency. We now see that this conclusion is derived, by a severely correct process of inductive reasoning, from a series of exact and laborious experiments and observations, and that the presence of these metals in the solar atmosphere has been determined with as great a degree of certainty as is attainable in any question of physical science.

The mode in which new and perhaps startling facts in science, such as those we are now considering, are unwittingly misinterpreted and misapplied by certain minds to suit their own preconceived notions, must be an interesting branch of study to the psychologist. The Heidelberg professors received a letter from a worthy farmer in Silesia thanking them for the great discovery they had made; it had particularly interested him, as it confirmed in a remarkable manner a theory which he had himself long held respecting the nutrition of plants: he believed that all artificial addition of inorganic materials to the plants in the shape of manure was quite unnecessary, as the plants obtained the alkalies, the phosphorus, and the silica, etc., which they require, if a sufficient supply be not present in the soil, from the *sunlight!* "The Heidelberg professors," he continues, "had clearly proved the presence of sodium, potassium, iron, and magnesium (all substances needed by plants) in the *sunlight*," and he felt sure that his theory of vegetable nutrition now required no further proof, but must at once be adopted by the previously incredulous world.

As a similar instance of this unconscious perversion of facts, we may mention the case of an English gentleman who believed that by a series of elaborate experiments he had proved the presence of iron in the *sunlight!* In spite of the previous caution of an eminent man of science, this gentleman was induced to publish his views, because, as he says, "the whole scope and object of Bunsen's and Kirchhoff's experiments are to prove the possibility of the most minute particles of metal existing in light, and the probability of certain dark lines in the solar spectrum being formed by iron!" Thus, the fact of the existence of iron in the body of the sun, at a distance of ninety-five million of miles, is represented by these scientific fanatics — we really can use no milder term — as being identical with the existence of iron in the sunlight, which, travelling at the rate of one hundred and ninety-two thousand miles per second, bathes the whole universe in its vivifying beams.

Of stellar chemistry applied to other self-luminous celestial bodies, we have at present but little knowledge. Fraunhofer, as we have already stated, observed that the spectra of the fixed stars contained dark lines differing from those seen in the solar spectrum. The half-century which has elapsed since Fraunhofer made these observations has not brought us further knowledge on this point, although it has assured us of the truth of his statements. In the spectrum of Sirius he observed no dark lines in the orange-colored region; but in the green there was a distinct line, and in the blue two dark bands, none of which were seen in solar light. The spectra of other stars were likewise examined by Fraunhofer, and they appeared each to differ from the other. The difficulties attending the exact observation and measurement of the dark lines in the spectra of the stars are, of course, very great; but, with the aid of the vastly improved optical instruments of the present day, we believe that astronomers will overcome these difficulties; and we look forward with interest to no far distant time when we shall receive some clue to the cause of the color of those wonderful blue and red stars which appear to be confined to certain quarters of the heavens.[1]

In the last chapter of Professor Kirchhoff's Memoir he puts forward a theory on the physical condition of the sun. Doubtless the professor is as well aware as any one can be of the great difference between his discovery of the existence of the metals in the sun and his physical theory of the solar constitution. One is an ascertained fact, the other is a mere hypothesis. It is, however, necessary to point out this difference, lest many who may not agree with the theory of the physical constitution of the sun proposed by Kirchhoff should think themselves at liberty to discard his discovery of the presence of the metals in the solar atmosphere. It is not possible here, however, to do more than quote one or two passages from his Memoir, to give an idea of his views respecting the structure of the sun: —

"In order to explain," he says, "the occurrence of the dark lines in the solar spectrum, we must assume that the solar atmosphere encloses a luminous nucleus, producing a continuous spectrum, the brightness of which exceeds a certain limit. The most probable supposition which can be made respecting the sun's constitution is, that it consists of a solid or liquid nucleus, heated to a temperature of the brightest whiteness, surrounded by an atmosphere of somewhat lower temperature. This supposition is in accordance with Laplace's celebrated nebular theory respecting the formation of our planetary system. If the matter, now concentrated in the several heavenly

[1] An examination of the spectra of the fixed stars has already been entered upon by Professor Airy, of the Royal Observatory of England.

bodies, existed in former times as an extended and continuous mass of vapor, by the contraction of which sun, planets, and moons have been formed, all these bodies must necessarily possess mainly the same constitution. Geology teaches us that the earth once existed in a state of fusion; and we are compelled to admit that the same state of things has occurred in the other members of our solar system. The amount of cooling which the various heavenly bodies have undergone, in accordance with the laws of radiation of heat, differs greatly, owing mainly to the difference in their masses. Thus, whilst the moon has become cooler than the earth, the temperature of the surface of the sun has not yet sunk below a white heat.

"Our terrestrial atmosphere, in which now so few elements are found, must have possessed, when the earth was in a state of fusion, a much more complicated composition, as it then contained all those substances which are volatile at a white heat. The solar atmosphere at this present time possesses a similar constitution. The idea that the sun is an incandescent body is so old that we find it spoken of by the Greek philosophers. When the solar spots were first discovered, Galileo described them as being clouds floating in the gaseous atmosphere of the sun, appearing to us as dark spots on the bright body of the luminary. He says that if the earth were a self-luminous body, and viewed at a distance, it would present the same phenomena as we see in the sun." — *Kirchhoff; Researches*, etc., p. 24.

Certain appearances connected with those spots on the sun's surface have induced astronomers in general to adopt a different theory of the constitution of the sun from that proposed by Galileo and supported by Kirchhoff. This theory supposes, according to Sir William Herschel, that the centre of the spot reveals a portion of the dark surface of the sun, seen through two overlying openings — one formed in a photosphere, or luminous atmosphere, surrounding the dark solid nucleus, and the other in a lower, opaque, or reflecting atmosphere. The supposition of the existence of such an intensely ignited photosphere surrounding a cold nucleus is, according to Kirchhoff, a physical absurdity. He puts forward his views on this point clearly and forcibly in the following passage: —

"The hypothesis concerning the constitution of the sun which has been thus put forward in order to explain the phenomena of the sun-spots, appears to me to stand in such direct opposition to certain well-established physical laws, that, in my opinion, it is not tenable, even supposing that we were unable to give any other explanation of the sun-spots. This supposed photosphere must, if it exists, radiate heat towards the sun's body as well as from it. Every particle of the upper layer of the lower or opaque atmosphere will therefore be heated to a temperature at least as high as that to which it would be raised if placed on the earth, exposed to the sun's rays, in the focus of a circular mirror whose surface, seen from the focus, is larger than a hemisphere. The less transparent the atmosphere is, the quicker will this temperature be attained, and the smaller will be the distance to which the direct radiation of the photosphere will penetrate into the mass of the atmosphere. What degree soever of opacity the atmosphere may possess, it is certain that in time the heat will be transmitted, partly by radiation, partly by conduction and convection, throughout the whole mass; and if the atmosphere ever had been cold, it is clear that in the course of ages it must have become intensely heated. This atmosphere must act on the nucleus in the same way as the photosphere acts upon it; the nucleus must likewise become heated to the point of incandescence. It must therefore give off light and heat; for all bodies begin to glow at the same temperature." — *Kirchhoff; Researches*, etc., pp. 25, 26.

Our author then proceeds to account for the phenomena of the solar spots by the supposition of two superimposed layers of clouds being formed in the solar atmosphere. One of these, being dense and near the sun's surface, does not allow the light of the underlying portion of the sun to pass, and forms the nucleus of the spot; whilst the other, being produced at a higher elevation, is less dense, and forms what we term the penumbra.

It is unfortunate for Kirchhoff's theory that the unanimous verdict of all who have examined these singular phenomena is in favor of their being funnel-shaped depressions. Preconceived notions have, however, so powerful an influence over the mind, and it is so difficult to obtain a truthful estimate of relative depression and elevation at such distances, that we are willing to believe that astronomers may possibly be mistaken in their views on this subject. There is, however, one method of observation which would seem qualified to settle the disputed question. If the astronomers' view of the construction of the spots is correct, the dark nucleus never can be seen beyond the penumbra, when the spot moves round towards the sun's limb. On Kirchhoff's view such a separation of the two clouds forming nucleus and penumbra is perfectly possible, and when they have nearly reached the edge of the sun's disc, we ought to see the dark cloud below, and separate from the upper one. Such a separation, however, has not been noticed; and, on the other hand, we may adduce the following observation of Sir William Herschel, as leading to a directly opposite conclusion: —

"Oct. 13, 1794. The spot in the sun I observed yesterday is drawn so near the margin that the elevated side of the following part of it hides all the black ground, and still leaves the cavity visible, so that the depression of the black spots and the elevation of the faculæ are equally evident."

The more the question of the physical constitution of the sun is considered, the more does it appear that we have no right to make up our minds concerning it, either in one way or the other. Seeing how little is really known about the matter, with the true spirit of scientific inquirers, we hold ourselves open to conviction as soon as satisfactory evidence shall be brought forward. The singular observations first made by Mr. James Nasmyth, a few months ago, concerning the physical condition of the sun's surface, — observations so novel that astronomers were loth to receive them as facts until they were confirmed by other observers, — need only to be mentioned in order to show that we are not in a position to uphold any theory whatever of the physical constitution of our great luminary. Mr. Nasmyth asserts, and his assertion has been confirmed by the subsequent observations of more than one competent observer, that the well-known mottled appearance which the surface of the sun exhibits is due to the presence of "willow-leaf-shaped" luminous bodies, which, interlacing, as it were, cover the whole surface of the sun. These most singular forms can be well observed, according to Mr. Nasmyth, in the "bridges" or streaks of light which cross the dark spots, and they are there seen to move with an astonishing velocity. Imagination itself fails to give us the slightest clue to the probable constitution of these most recent of astronomical novelties!

The beautiful red prominences seen projecting from the sun's disc during a total solar eclipse, and reaching to a height of forty thousand miles above the sun's visible surface, are likewise objects whose existence cannot be reconciled with any of the proposed theories of the sun's structure. — *Edinburgh Review.*

Mitscherlich's Researches on Spectral Analysis. — In examining with the spectroscope a substance containing baryta, M. Mitscherlich observed two bright green bands which appeared to indicate the presence of a new metal. On further investigation it was found that the same lines were obtained, sometimes alone, sometimes together with the barium lines, when a solution of chloride of barium containing salammoniac is employed. Acting upon the data thus obtained, M. Mitscherlich continued his investigations, and has been led to the conclusion that metals do not give a spectrum in all their compounds, and that they do not give the same spectrum in different compounds, but that the character of the spectrum depends upon whether it is produced by the metal, or by one of its compounds of the first order. It further appears that every compound of the first order, if it have a spectrum other than that produced by decompositon, must have a spectrum of its own. Metallic compounds are so easily reduced by the flame that we usually obtain only the spectra of the metals themselves. Light passed through ignited soda vapors, or vapors of the carbonate of soda, does not give the sodium line; but the vapor of metallic sodium, at a low red heat, exhibits this line distinctly. From this it follows that in those flames which exhibit the sodium line, metallic sodium, as such, produces the line in question, and since sodium has almost the greatest affinity for oxygen, it follows that all spectra which are produced by oxides are metallic spectra. The author further suggests that these experiments enable us to determine the affinities of the elements at the temperature of the sun's atmosphere by the spectral analysis. If, for instance, we observe the spectrum of a particular metallic chloride in the sun's light, we should have to conclude that at the temperature of the sun's atmosphere the metal in question has a greater affinity for chlorine than potassium or sodium, since these exist as metals in the sun's atmosphere. Moreover, we may hereafter, conversely, determine the temperature of the sun's atmosphere from the nature of the chemical compounds which exist in it, provided that we succeed in obtaining an approximately high temperature.

From the fact that free potassium and sodium exist in the sun's atmosphere, it follows that no free electro-negative body like oxygen, sulphur, etc., can be present, and not even enough to combine with all the sodium. Consequently all metals which are reduced from their compounds by sodium must exist in the sun's atmosphere in the free state.[1] The absence in the solar spectrum of the lines of a particular metal does not prove the absence of the metal itself, since it may exist in combination with some element, the compound itself exhibiting no spectrum. The many new lines recently discovered in the spectrum, and to which no elements are known to correspond, may prove to be the lines of compounds of the first order of metals already known. — *Pogg. Ann.* cxvi. 499.

Spectrum Analysis in Lecture Rooms. — M. Debray, of Paris, has successfully carried out the idea of projecting the spectra of flames colored by the metallic elements upon a screen by means of a Drummond light. The combustion of coal gas sustained by atmospheric air gives too pale a flame when metallic substances are introduced into it to enable us to see the spectra clearly except with the aid of a telescope; but if we take the exceedingly hot jet of an oxyhydrogen blow-pipe, colored by various metals, the splendor it acquires is so brilliant that it becomes very easy to project the spectrum upon a screen, so as to be seen distinctly by an audience. To this end, the flame is introduced into Duboscq's photographic apparatus, now so generally employed in optical experiments, and proceed precisely as in obtaining the spectrum from an oil lamp, or from the voltaic arc. We then obtain, upon a screen suitably adjusted, the series of brilliant and vari-colored rays which characterize the metal introduced into the flame. These experiments are successful not only with the alkaline and earthy alkaline metals, but also with other metals, such as copper and lead, although these bodies give, with a gas flame, and the ordinary apparatus, only a very confused phenomenon. As platinum melts instantaneously in the flame of the blowpipe, the metallic substance is introduced by means of the small piece of retort-coke, or by a match strongly impregnated with the matter to be experimented upon, which will be preferably selected from the metallic chlorides. With a little practice we can sustain the phenomenon long enough to study all its details at a very great distance.

Homœopathic Medicines and the Spectroscope. — Dr. Chas. Ozanam states in the *British Journal of Homœopathy* that a spectroscope by Steinheil enabled him to recognize lithium in the fifth dilution of its chloruret, a drop containing five billionths of a milligramme. The milligramme is one thousandth of one gramme, which is a minute fraction, less than fifteen and one-half grains. He detected sodium in a drop of the sixth dilution of its chloruret, which weighed three centigrammes, and contained three hundred billionths of a milligramme.

[1] In regard to this conclusion of M. Mitscherlich, Dr. Gibbs, in *Silliman's Journal*, remarks as follows: It does not appear to be justified upon chemical considerations. For it may be that the oxids, sulphids, chlorids, etc., of sodium and potassium are decomposed into their elements at the temperature of the sun's atmosphere, and consequently sodium, potassium, oxygen, sulphur, chlorine, etc., may be coëxistent in the free state in the sun's atmosphere, and there may be far more than enough oxygen, etc., to combine with all the potassium and sodium. It would be unsafe to argue that because oxygen is the most abundant terrestrial, it must also necessarily be the most abundant solar element, yet such is possibly the case. Moreover, it is not necessarily true that all metals which are reduced from their compounds by sodium must exist in the sun's atmosphere in a free state, because the masses or absolute quantities, as well as the temperatures, must be taken into consideration in judging of the affinities actually controlling combination.

Mitscherlich's experiments are certainly of great interest, and, in fact, form the second great step in our knowledge of the constitution of the sun's atmosphere.

Doubts respecting Bunsen and Kirchhoff's Results. — The London *Photographic News* makes the following remarks on the present state of our knowledge respecting "spectrum analysis:" —

The subject is affording grounds for much scientific debate, and the opinion is gradually gaining ground that there are many reasons, experimental as well as theoretical, for concluding that the sweeping explanation of the cause of Fraunhofer's lines given by the German savans, Bunsen and Kirchhoff, is, to say the least, open to great doubts. Prof. Miller, at a late meeting of the London Pharmaceutical Society, urged the necessity of still considering the views of Kirchhoff and Bunsen as theoretical, there being many points which presented anomalous features. Some spectral lines, he said, were due to the incandescent metals, but others undoubtedly belonged to the atmosphere, or to the different gases in which the ignition of the metal took place. The rise of temperature, too, evoked different lines from the same substance. Chloride of lithium, in a Bunsen burner, gives a single crimson ray; in the hotter flame of hydrogen an additional orange ray appears; whilst the oxyhydrogen jet, or the voltaic arc, brings out a broad, brilliant blue band in addition: the same takes place with sodium and other metals. Fascinating as the German theory is, it must be remembered that it is still upon trial, and that it does not yet explain the facts known respecting the vapors of hydrogen, mercury, chlorine, bromine, sodium, or nitrogen.

HELIOCHROMY.

M. Niepcé de St. Victor has communicated to the French Academy an important step towards the fixation of heliochromic tints, which increases the hope that before long colored objects may be successfully photographed. He states that he "obtains the heliochromic colors on a film of chloride of silver formed on a metallic plate." In preparing this plate he employs hypochlorite of potash, and he remarks, — "This alkaline bath, although very variable in its composition, generally gives fine colors, only the bottom of the image remains somewhat dark, and divers causes occasion certain colors to dominate over the rest." Continuing his description, he observes, — "It is known that to obtain the colors on a white ground it is necessary to heat the plate, before exposing it to the light, until the chloride of silver assumes a rosy tint, or to substitute for the action of heat that of light, in the manner indicated by M. C. Becquerel. I conceived the idea of covering the chloride film, before exposing it to the light, with a layer of a saturated solution of chloride of lead mixed with enough dextrine to form a varnish." He found that the colors were produced with greater brilliancy on a plate thus prepared, and after their appearance the plate was heated over a spirit-lamp, not raising the temperature high enough to carbonize the varnish. "Under the influence of heat, the colors usually grow more intense, especially if the light has influenced the whole thickness of the chloride of silver; but if otherwise, the blues are turned into violets, and the blacks to reds." The result of the process is, "that the destructive action of light upon the plate is retarded, so that ten or twelve hours are necessary to destroy the colors, which, under ordinary circumstances, would disappear in a few minutes. Such is the state of heliochromy to-day, and if the problem of fixation is not yet solved, we may at least hope for a solution." M. Chevreul remarks that the discovery of the dextrine and chloride of lead varnish is a great advance, and he compares the sensitive films of M. St. Victor to the retina of the human eye.

M. Chevreul, in commenting on these new results, called the attention of the Academy to the remarkable facts connected with them, — the first of which is, that the image produced by the sun is direct, and not inverted, like those obtained by ordinary methods; and the second, that the light whitens the parts which it strikes, through a special action of the dextrine and chloride of lead varnish, while without this varnish it would impress a violet tint on the chloride of silver of the daguerreotype plate, — a remarkable result, since M. Niepcé has observed that the shadows of an engraving are reproduced in black on plates prepared with his varnish. The colors of the image are not produced simultaneously; for example, the yellow appears before the green, and when this latter is manifested the yellow is weakened, if not effaced. Does it not follow from this that the way to reproduce the colors with fidelity would be by the use of screens, so arranged as to cover the parts where the colors are first exhibited, so as to give more time to other colors which require it?"

THE PROSPECT OF OBTAINING PHOTOGRAPHS IN NATURAL COLORS.

Sir David Brewster, in a recent publication, thus sketches the progress of heliochromy, and gives his views respecting the prospect of the ultimate solution of the problem of fixing the colors of nature upon a photographic picture. He says: —

More than one philosopher has expressed the opinion that the finely-colored picture which appears with all the tints of nature on a sheet of white paper placed in the camera can never be reproduced and fixed either upon a paper or a metallic surface. This is the principal discovery which science has in store for photography; and from the successful attempts which are making to reach it we are not without hopes that it may yet be accomplished.

In 1840 Sir J. Herschel obtained upon photographic paper a colored image of the solar spectrum. Daguerre had previously observed that a red house gave a reddish image on his iodized plate in the camera; and Mr. Fox Talbot had observed that the red of a colored print was red when transferred to paper washed with chloride of silver. On paper washed with chloride of barium and nitrate of silver, Mr. Hunt obtained *red* under a *red* glass, a *dirty yellow* under a *yellow* glass, and a *light olive* under a *blue* glass. By preparing metallic plates with chlorine, M. Becquerel obtained the spectrum in colors, and also colored impressions of highly-colored maps; but, though these colors were long durable in the dark, he never succeeded in fixing them.

M. Niepcé St. Victor, setting out from the fine researches of M. Becquerel, has been more successful by using the purest silver; and Mr. Hunt informs us that he has "examined pictures on metallic plates, produced by Niepcé, in which every color of the original was most faithfully represented," but they "slowly faded out, and became eventually one uniform reddish tint." In M. Niepcé's early experiments, made in 1851 and 1852, and published in three memoirs on heliochromy in the *Comptes Rendus*, he obtained his colored pictures by preparing a bath composed of the deuto-chloride of copper; but in his more recent researches he has discovered a very remarkable action of the chloride of lead in the double relation of white and the duration of the color of the image submitted to the influence of light.

The colors of the landscape have been accidentally produced in the operations of photography. Mr. Raymond, a French artist, when developing a picture on collodion by a combination of pyrogallic and acetic acids, exposed it to light without washing it, and observed it transform itself quickly into a positive, assuming, with more or less perfection, the colors of the model. The best picture he obtained required a quarter of an hour for its development. It preserved its colors by an exposure to the air for some months, and was not completely effaced at the end of two years.

Several photographers have observed colors in their landscapes; but they are the colors of thin plates, and have no relation whatever to the colors of nature.

In a memoir published two years ago, M. Niepcé has shown how to produce red, green, violet and blue photographs. A fine *blood-red* color is produced by a solution of twenty parts of nitrate of uranium in one hundred of water. The paper, after being fifteen or twenty seconds in this solution, is dried in the dark. It is exposed for eight or ten minutes under a negative, washed for a few seconds in water at 50° or 60° Cent., and then immersed in a solution of red prussiate of potash, composed of two parts to one hundred of water. It then has a fine blood-red color, and must be washed repeatedly till the water is limpid. A *green* color is obtained by immersing the preceding red paper in a solution of nitrate of cobalt. When taken out and dried at the fire without washing, its color will be green. It is then fixed by putting it for a few seconds in a solution of sulphate of iron and sulphuric acid, each four parts in one hundred of water. It is then passed once through water and dried. A *violet* picture will be obtained, with the paper prepared as above, with nitrate of uranium. When it is taken from beneath the negative, it is washed in warm water, and developed in a solution of chloride of gold, of one-half part to one hundred of water. When it has taken a fine violet color, it is washed several times in water and dried. In order to get a *blue* picture, the paper is prepared with a solution of prussiate of potash, twenty parts to one hundred of water. It must be taken from beneath the negative when the insulated parts have a light blue tint, and then put for five or ten seconds into a cold saturated solution of bichloride of mercury. When washed once in water, and a cold saturated solution poured upon it of oxalic acid, at the temperature of 50° or 60° Centigrade, it is then washed three or four times and dried.

CELESTIAL PHOTOGRAPHY.

At the Leeds meeting of the British Association, Mr. De La Rue exhibited binocular lunar pictures, which, when combined in the stereoscope showed the moon as a sphere. Our readers will understand how such a remarkable result has been obtained, by considering that binocular pictures of a statue may be taken with a fixed camera, by making it move round its axis through the binocular angle, and taking the two pictures in succession. Now, though the moon has not a motion of rotation relative to the earth, yet it has a libratory motion through an arc of twenty-one degrees, which is more than sufficient to give a right and left eye picture of it; and Mr. De La Rue, having taken photographs of her at two epochs of maximum libration, has succeeded in producing the wonderful result of exhibiting the moon in the stereoscope with all the roundness of a sphere. As the stereoscope has the remarkable property of exhibiting effects which are not seen in the single picture, several of the radiating lines in the single moon's disc have been found by Mr. De La Rue to be furrows, one of which, extending from Tycho, is fifty miles wide.

Mr. De La Rue has also taken photographs of Jupiter, which "show the configuration of the belts sufficiently well to afford the means of producing stereoscopic pictures." In the space of twenty-six minutes, the planet will have rotated through the binocular angle. Mars will rotate through the same angle in sixty-nine minutes; and as the markings are very distinct, Mr. De La Rue hopes to obtain stereoscopic views of that planet. From the opening and closing of Saturn's ring, Mr. De La Rue expects to obtain a stereoscopic picture of him, having already obtained an approximate result from the union of two drawings which he had made in November, 1852, and March, 1856.

In the photographs of the sun obtained by Mr. De La Rue, the faculæ and the spots, with their penumbræ, are finely seen. When the collodion is over-exposed, the faculæ first disappear, then the penumbræ, and then the spots. The spots and faculæ bear a magnifying power, and show details not visible to the unassisted eye. Good binocular pictures, taken at the interval of a day, when united, show the sun as a sphere in the stereoscope.

In 1858, Father Secchi, of Rome, sent to the Academy of Sciences, in Paris, a photograph of the moon, eight inches in diameter, in the seventh day of her age, having taken her picture in various other phases. He obtained, also, a photograph of Jupiter, which showed his belts very distinctly, and also traces of some of his satellites. It took twice as long time as the moon the day after the full, so that the force of light (actinic rays only) in Jupiter is greater than that of the moon, seeing that their distances from the sun are as five to ten. Father Secchi sent also to the Academy, in the same year, a photographic atlas, in which the moon's diameter was eight inches, from negatives about two inches in diameter, enlarged with a great solar microscope. He had obtained, also, an excellent photograph of Saturn, which, though only the twenty-fifth of an inch in diameter, not only showed the black spaces between the planet and the ring, but *the shadow of the planet on the ring.* It bore to be magnified to a diameter of one and a half or two inches, and established two remarkable facts: first, that the planet was "more sombre" than the ring; and, second, that the light of the planet (the actinic rays only) was stronger in proportion than that of the moon; for the full moon was obtained in twenty seconds, and Saturn was solarized in eight minutes, or one hundred and sixty seconds. The proportion of these times is as one to twenty-four; whereas, according to the law of the distance, it ought to have been as one to eighty. This result he considers as proving that Saturn has a reflecting atmosphere, as he inferred that Jupiter had, from its superior photogenic power.

NOVELTIES IN PHOTOGRAPHY.

Photography by Absorption. — A singular photographic process, which has been called photography by absorption, has been described by M. Niepcé de St. Victor, under the name of *a new action of light.* If an engraving, which has been kept several days in the dark, and exposed fifteen minutes to the sun, is kept four hours in contact with a sheet of sensitive paper in the dark, a negative picture of the engraving will be obtained. If a space of one-eighth of an inch, or a film of collodion or gelatine, be interposed between the engraving and the sensitive paper, a picture will still be obtained; but not if a film of mica, glass, or rock crystal be interposed. In order to show this action more satisfactorily, M. Niepcé took an opaque tube, closed at one end and lined with white paper, and having exposed the open end to the sun for an hour, he placed at that end a sensitive paper, which, after twenty-four hours, exhibited a negative image of the opening. The following experiment is still more interesting. M. Niepcé took a sheet of white paper that had been long in the dark, and, having placed it in the camera, he exposed it to a picture brilliantly illuminated by the sun. When it was taken out and applied to a sheet of sensitive paper, there was reproduced in twenty-four hours a very visible copy of the brilliantly-illuminated picture.

This new action of light, to which M. Niepcé has given the name of the *persistent activity* or *storing up of light*, is finely shown in the following experiment: — A negative on glass or paper is placed on a sheet of paper that has been several days in the dark, and exposed for a sufficient time to the sun's rays. When taken out in the dark, a copy of the negative is brought out by a solution of nitrate of silver, and fixed by washing in pure water.

In continuing these important researches, M. Niepcé has shown that photographic pictures may be obtained from almost all chemical actions. If a sheet of paper, for example, is impregnated with any soluble substance, and dried in the dark, it will receive an impression from a negative when exposed to the sun. This impression will be developed if the picture taken out in the dark is treated with any reagent capable of transforming the soluble substance, or entering into combination with it. A result the reverse of this will be obtained if the paper is impregnated with the reagent and developed with the soluble substance. The salts of gold and silver, the dyes of turnesol and curcuma, and iodide of potassium for common paper sized with soap, are the most important reagents to be employed. If the nitrate of uranium is the soluble substance, and the red prussiate of potash the reagent, the picture will be of a fine *blood-red* color, and may be fixed by pure water. If the picture is put into a solution of any salt of copper without washing, it will assume different shades, according to the degree of heat employed. If the reagent is a prussiate of iron, the color of the picture will be a *beautiful blue*.

Military Photography. — The French Minister of War has recently decided that in each corps of the army there shall be an officer skilled in photography. In every campaign he is to follow the expeditionary corps. To this officer is assigned two subordinates, in the capacity of photographic aids, and six soldiers are detailed to serve as assistants. The apparatus employed is necessarily limited, consisting of objectives adapted to long distances, and which can be easily packed in a single wagon.

Restoration of Faded Photographs. — The greatest defect of photography as an art is, that its pictures are more perishable than the material which bears them. Many of them, indeed, have disappeared, and left the paper on which they were drawn in all its original whiteness. This fading of photographs has been ascribed, we believe justly, to the imperfect removal by hot or cold water of the hyposulphite of soda used in fixing them; and for a long time photographers have endeavored to get rid of this injurious salt. It is fortunate, however, for the credit of the art, that a method of reviving faded photographs has been discovered, and the following process has been published by MM. Davanne and Girard: — "Place the print in a solution of chloride of gold, and leave it in this bath for three or four hours, if shielded from the light, or for a few minutes, if under the influence of the solar rays. In other respects, follow the ordinary course, pass through hyposulphite of soda, and *the print, however faded*, will be revived."

New Mode of Copying Engravings. — M. Brettiger suggests a very simple method of reproducing, by chemical means, an engraving from a steel or copper plate. Dissolve in 1,500 parts of pure water 16 parts of pure, concentrated sulphuric acid, and to 200 parts of the mixture add one-half part of iodide of cadmium. This last mixture is poured into a dish, and the engraving is immersed in it, and left till it has become thoroughly impregnated with the liquid; it is then placed upon folded sheets of white blotting-paper, on a plate of glass, and the excess of moisture removed from the engraving. It is then placed printed side downward upon a sheet of writing or of positive paper, and placed in a press. An impression is obtained as delicate as that furnished by photographic processes. The iodide of cadmium may be replaced by iodide of potassium. The reproduction is due to the reduction of the iodine by the black in the ink of the engraving, and the liberated iodine acts upon the starch with which the paper is sized. The engraving will give a second impression without being returned to the solution. When the engraving has been used several times, it is only necessary to wash it in water to remove the spots that may have formed. Lithographs and ordinary printed matter cannot be reproduced by this process, on account of the nature of the printing ink, but writing ink succeeds very well. Unfortunately, these beautiful impressions become blue all over, and are gradually effaced, even if covered with a coat of varnish.

Autographs of the Sun. — At the meeting of the British Association, 1862, Prof. Selwyn showed several "autographs of the sun," taken with his "heliautograph," which consists of a camera and instantaneous slide, by Dallmeyer, attached to a refractor of 2¾ inches' aperture, by Dollond; the principle being the same as that of the instrument made at the suggestion of Sir J. Herschel for the Kew Observatory. Three of these autographs were taken on the 23d day of August, 1862, and two of them had the edge of the sun in the centre of the photographic plate, showing that the diminution of light towards the edges of the disc is a real phenomenon, and not wholly due to the camera. In two of the 4th of August, where a great spot (20,000 miles in diameter) appears on the edge, a very distinct *notch* is seen, and the sun appears to give strong evidence that the spots are cavities; but eye observations and measurements by the Rev. F. Howlett, and others, tend to show that this evidence is not conclusive, for there was still a remaining portion of photosphere between the spot and the edge. The phenomena shown in these autographs appear to confirm the views of Sir J. Herschel, that the two parallel regions of the sun where the spots appear are like the tropical regions of the earth, where tornadoes and cyclones occur, and those of Wilson in the last century. The *faculæ* seem to show that the tropical regions of the sun are highly agitated, and that immense waves of luminous matter are thrown up, between which appear the dark cavities of the spots, whose sloping sides are seen in the penumbræ, as explained by Wilson and others.

By means of photographs of the sun, taken every fine day at the Kew Observatory, England, we are now obtaining a continuous history of the changes in the spots and faculæ on its face, more accurate and more instructive than could be procured by any verbal description or ordinary drawing. By this means, questions relating to the periodicity of these changes, and their connection with terrestrial magnetism, will be solved, and likewise those concerning the movements of the supposed ring of asteroids in the region of Mercury.

Micro-Photographs. — The Abbé Moigno gives a most enthusiastic account of the new method of preparing and exhibiting micro-photographs invented by M. Dagron. After describing a process by which a series of the minute sun pictures are taken in rapid succession, he proceeds to inform us that a number of cylinders of common or flint glass are prepared in advance, about five or six millimetres long and two thick. One extremity of these cylinders is spherically rounded in a hollow, to transform it into a magnifying lens; while to the other extremity of the cylinder a micro-photograph is fixed with Canada balsam, and the edges ground by an optical tool to efface the marks of the union. This is the photo-micrographic cylinder.

Photo-zincography. — From the first introduction of daguerreotypes to the present time, there have constantly been attempts to etch the photographic image or to transfer the solar picture to stone. The photo-galvanographic process will be familiar to many, and Mr. Fox Talbot's engravings have been widely displayed. From time to time, too, photo-lithography has promised great results; but both in this country and in Europe difficulties have arisen in practice which have prevented success. Nearly all of these processes have been founded on the use of the bichromate of potash in contact with gelatine or some analogous organic body.

"Carbon-printing," as introduced into the art of photography by Mr. Pouncey, involved the use of the bichromate of potash and gelatine mixed with finely-divided carbon. Those portions of a surface so prepared which were screened from solar influence would dissolve entirely off; whereas the parts which had undergone actino-chemical change remained permanent, giving a black picture.

These are the steps which have led onward to the process "photo-zincography," which has been brought to a high degree of perfection by Col. Sir Henry James, of the British Ordnance Survey, who has recently published a work giving a full detail of all the steps of the operation, with illustrations of the results obtained. The process is substantially as follows:—"If a solution of gelatine and bichromate of potash is spread on paper, and when dry exposed to light under a negative of an engraving or a plan, the lines of the drawing will be represented by insoluble lines on the coated paper; while the ground, having been protected from the action of the light by the dense negative, will remain soluble. If the paper is now coated with greasy printer's ink and damped at the back, the soluble parts will swell and the lines will be in intaglio; and when rubbed gently with a sponge dipped in gum and water, the ink overlying the soluble parts (now again viscid and in a dissolving state) will be removed, while it will adhere to the insoluble parts. The engraving or plan will then appear in black ink, which can be transferred to the surface of zinc or stone. This is the gist of the whole process; but, though it appears so simple, in practice it requires care and judgment, and many difficulties were met and overcome before very good results were obtained."

Among the illustrations of photo-zincography given in Sir Henry James' book, there is, for example, a copy of a page from the folio Shakspeare of 1623, which shows that rare and valuable printed books may be reproduced with unerring accuracy. There is also a page of the Domesday Book, which proves that by photo-zincography the most faithful copies can be obtained of ancient manuscripts. Two of Piranesi's engravings of antique vases,—a part of one of the engravings by Volpato of the panels in the Vatican painted by Raphael,—and a reduced copy of an engraving by Dorigny, from the original, by Raphael, show how truthfully, with every touch of the original engraver, such works can be reproduced.

When we remember the facilities which are offered for copying, and varying the scale as we please, of any printed or written matter, of any map or plan, or of any engraving, we must be convinced of the value of photo-zincography.

PHOTOGRAPHY AND FORGERY.

We derive from the London *Photographic News* the following article on the above subject:—The facilities afforded by photography, and more especially by photo-lithography, for effecting forgeries of bank notes and other documents, appear to have been considerably overlooked by those who are, or should be, most concerned. The sources of danger have been looked for in other directions, and it is from the imitative skill of the skilful engraver that counterfeit productions have been feared. In regard to Bank of England notes, a great safeguard has been believed to exist in the inimitable character of the paper, in quality, design of water-mark, etc. But since the robbery of bank note paper this reliance has vanished into thin air, as the genuine paper manufactured for the bank authorities is now actually in circulation as the basis of the forgery. The bank authorities themselves rely upon the simplicity of the design and characters upon their notes, and upon the mode of printing adopted, as their surest protection against imitation. Others maintain that complexity of design, produced by artists of the first ability, is the truest source of safety, arguing that, notwithstanding the skill and enterprise which have, unfortunately, been engaged in the nefarious profession of the forger, it must always happen that genuine art will be in advance of the spurious or counterfeit art. It is further argued that the number of persons who would be able, with any chance of success, to imitate the designs of genius, must necessarily be very few, and "these," as it is argued by an old writer on the subject, "by the legitimate use of their talents, can acquire competence; they, therefore, are not likely to employ their time, or risk their lives, in felonious imitations. Nay, if, in the perversity of the human mind, a first-rate artist were inclined to turn forger, he could not then do it successfully, because, even in the very first rank of historical engravers, one cannot imitate the engraving of another in a work of importance without the difference of manner being visible."

Adopting these and similar arguments, the bank authorities have held, we believe, that their position was impregnable, and that the precautions against forgeries of their notes were as complete as it was in the nature of things, or at least in the present state of science, possible to make them. Moreover, they may, and we believe do, argue, no forgery has ever yet been executed which they could not themselves detect; and as they could only become losers by counterfeits produced with such skill as to deceive their own tellers, and induce them, without question, to convert them into specie, they were not called upon to entertain further anxiety upon the subject. They believe that their own safety from deception is absolute, and that, for the public safety, they have done sufficient, or, at least, all that was possible; and there the matter must rest.

But the imitation produced by photography is absolute in all its parts. The most complex design of the most skilful artist is as easily produced as the most simple common-place production of the greatest bungler. The secret marks, however unobtrusive; the signature, no matter how marked its individuality or character, are all unerringly produced by the lens and camera, in the negative image. The ordinary silver print from such a negative, it is true, whilst it might deceive some persons if well executed, would speedily be detected on careful examination. It is for this reason, we doubt not, that the subject has received comparatively little attention, and excited no apprehension hitherto. But this is not the real danger. It is from the processes of photo-lithography, photo-glyphography, and similar processes, by which photographic impressions can be produced in printer's ink, in the very material, and of the exact tint, of the original, that the danger is to be apprehended; and that danger threatens the bank authorities themselves as well as the public, for it is possible to produce, by these means, imitations, which not the most skilful teller or the most practised expert could detect or make oath as to the forgery.

Let us take the case of photo-zincography, photo-lithography, or the processes which have at present attained the highest state of perfection. The results of these processes, in the shape of *fac-similes* of maps, engravings, manuscripts, pages of printed books, etc., were exhibited at the International Exhibition, in a shape to absolutely defy detection as copies. But it is said that the inventors of these new processes are gentlemen from whom there is no danger of forgery. But their processes are made public, and not only may be, but actually are, practised by others. In fact, Mr. Osborne, the inventor of photo-lithography, wishing to call the attention of bankers in Melbourne to this danger, produced to them photo-lithographic copies of which they admitted they would be unable to repudiate the genuineness. Any color of ink, resembling either printing or writing ink, or any number of colors, may, of course, be easily produced, so that an actually written signature, instead of the printed signature now used, would not be an absolute safeguard.

We do not enter at present into any extended examination of the means by which such forgeries might be prevented, our object being rather to call the attention of those concerned to the existence and imminence of the danger. The means of prevention require careful consideration, and are not so easy and simple as might at first sight appear. Some years ago the subject came under consideration in the United States and in Canada. Colored inks were employed for some parts of the note, and black for the other; but it was found that the colored inks, not possessing, like black, a carbon basis, were easily discharged by chemical means, and photographic copies of the remainder easily produced, the colored portion being supplied by a subsequent operation. This difficulty was subsequently met by the use of a green formed of the oxide of chromium, which resisted the action of chemical reagents. A geometrical pattern in this color was printed first all over the paper, and the value, denomination, etc., of the note, subsequently printed upon that in the usual way with black ink. This was an effectual check to ordinary photographic imitation, but it would be little or no check to the photo-lithographer, whose art would furnish him with means of evading this difficulty. A variety of means might be suggested of making the imitation difficult, but they would require more consideration than we can now give to the subject.

NEW METHOD OF MAP CONSTRUCTION.

At a recent meeting of the Franklin Institute, Mr. Sartain, the well-known engraver, exhibited a map, devised and executed on a new plan, by Baron Egloffstein, for illustrating the labors of the United States expedition for exploring the Colorado River of the West.

Baron Egloffstein, the topographer of the expedition, conceived the idea of endeavoring to give his map the appearance of a small plaster model of the country; and to do this he treats the forms of nature as an artist would draw any form before him, — that is, by giving the real light and shade that would be developed by the light falling on the model at a suitable angle. The mountains have their shadow-side engraved in the usual manner by "*hachures*," but the light-side is only slightly tinted in parts, to develop detail of form, and is brilliantly relieved by a tint spreading over the level plain like an India-ink wash; this tint is made of several grades of strength, intended to show the *relative altitude* of the several plateaus over which it is spread, the lowest or alluvial lands having the darkest tint, and the loftiest table-lands having the most delicate.

The result in the present map is bold and striking, showing at a glance the nature of the whole country, enabling any one to perceive the character, prominence, and relation of the different parts. This region of country has features unsurpassed in their kind for grandeur and sublimity; the Colorado of the West flowing for 300 miles of its course through cañons whose sides often rise perpendicularly from 3,000 to 6,000 feet in height; while the "Great Cañon of the Colorado" is the most magnificent gorge, as well as the grandest geological section, of which we have any knowledge. For this region Egloffstein's system of mapping has unquestionable advantages. Its freedom from conventionality and truth to nature give it a power, unattainable by the old system, of representing forms so that they are intelligible to every eye. The French, at one time, used a system of topography similar to this. It had light-sides and shade-sides to the mountains, but they did not tint the level plains, on which so much of the character and beauty of this style depends.

M. FAYE ON SOLAR REPULSION.

The following paper by the well-known French astronomer, M. Faye, is translated from the *Comptes Rendus*, March, 1862: —

It follows, from a consideration of all the facts relating to the acceleration of comets, and of the forms they assume, that there exists in celestial space a repulsive force, exerted by the surface of the sun; that this force is due to incandescence, and operates like attraction at all distances. The physical phenomena which surround us afford striking indications of a force of this nature, and we can put them in evidence by causing an incandescent surface to act under the conditions which are revealed to us by the study of astronomical effects. There is thus an identity between the two forces which have their origin in heat, just as there is an identity between celestial attraction and terrestrial attraction, as shown by the fall of heavy bodies in the celebrated experiments of Maskeleyne and Cavendish. But repulsion exerted at a distance by an incandescent surface cannot be a different thing from the molecular repulsion which is equally due to heat, — the force to which physicists attribute the phenomena of dilatation, of changes in the state of bodies, and their elasticity in the gaseous form. We arrive then at the conclusion that there exists in nature a force not less general than attraction, and which, like attraction, manifests itself in celestial spaces, as well as in molecular intervals.

There is, however, a difficulty which seems to oppose this complete identification. The molecular repulsion due to heat has always been considered as a force which disappears at any appreciable distance from its centre of action, and it has this character, whether we admit with Newton an interruption of continuity, or prefer to have recourse with Laplace to the remarkable hypothesis of forces whose sphere of activity does not extend to sensible distances. . . . . Laplace thus expresses himself on this subject: After having calculated the pressure in a gaseous mass, bounded by a spherical envelope, in accordance with the hypothesis of a repulsive force with an indefinite sphere of activity, he shows that the law of repulsion adopted by Newton is far from representing the conditions which this constant pressure exhibits, and he then remarks: "This great geometer does indeed assign to this law of repulsion an insensible sphere of activity; but the manner in which he explains its wants of continuity is little satisfactory. We must, without doubt, admit a repulsive force between the molecules of the air, which is only operative at imperceptible distances. The difficulty consists in deducing from it the laws of elastic fluids, and this can only be done by the following considerations." These considerations take for their point of departure the formulæ by which the mutual attraction of spherical bodies is determined, and a simple change of sign enables us to pass from a case of attraction to one of repulsion.

No one will deny the necessity for this narrow limitation of the sphere of activity assigned to molecular force, but must we therefore conclude with Laplace that it is a special force, distinct from the great forces of nature, which operates at all distances? No. It is easy to see that the repulsion due to heat, and defined by its astronomical characters, exhibits precisely the phenomena of forces with an insensible sphere of activity, although in free space it operates at all distances. That which conceals the true explanation is, that our minds, for a long time habituated to speculations on Newtonian attraction, experience a difficulty in considering forces of a totally different nature, and if we speak of repulsion we conceive of it only as an attraction with a change of sign, and philosophers like Bessel only see a negative attraction in the repulsion so visibly exerted by the sun. But it is not so. Solar repulsion, as exhibited in the movements and figures of comets, differs widely from a negative attraction, first by its successive propagation, and, secondly, that it does not pass through matter as the attractive force does. It is in this last characteristic that we find the key of the difficulty, and it is in harmony with all the evidence collected in my researches, and on which I have had to insist so often during the last three years. For if we consider the essential character of the repulsive force, we shall easily perceive that it assumes in all bodies the conditions of a force with an insensible sphere of activity. Each molecule of a body is in fact surrounded, at an inappreciable distance, by other molecules which receive its repulsive influence, and at the same time behave to it like a screen. And as these molecules are not mathematical points, and as their dimensions are considerable when compared with the intervals which separate them, the repulsion due to heat — an action of surface, exhausting itself on the surface of the body which it affects — will find itself sensibly reduced beyond the limits of the molecules surrounding each centre of action. We may further conceive that the radius of this boundary, that is to say, the sphere of activity of each molecule, may be equal to a definite number of times the interval between the several molecules, and thus, belonging to the same order of minute magnitudes as they do, may be equally inappreciable. To this remark, M. Faye adds in a note that, instead of being an absolute quantity, this radius may depend upon temperature, and he then observes: Thus the repulsive force which acts at all distances in celestial spaces finds itself reduced in the interior of bodies to an action at insensible distances, and consequently, in all that concerns the mechanical action of heat, a special hypothesis, like that of Laplace, is useless, as everything is explained on the supposition of force distinct from Newtonian attraction, but not less general in its operations. Is it not remarkable that we have to seek in the heavens for the essential characteristics of the two great forces which govern the material universe?

CONSERVATION OF ORGANIC FORCE.

In 1842 M. Mayer, guided by his knowledge of the correlation of the physical forces, first deduced the general principles of the conservation of organic force, in which he was followed, in 1855, by Prof. Helmholtz. For machines there is necessarily a motive power. The machinists of the last century, unaware of the law of conservation of force, sought to find out perpetual motion, and they thought they had examples in the bodies of every animal, where motion seemed produced every day without any supply of mechanical power. Compare, then, living bodies with a steam-engine (and the comparison is accurate); they take in food — the equivalent of fuel — in the form of inflammable substances, as fat; hydro-carbons, as sugar; nitrogenous substances, as albumen, flesh, cheese, etc.; and so, also, they take in, by respiration, oxygen.

Living bodies give off, like the steam-engine, the products of combustion. Suppose we weigh an animal on two occasions, and find it exactly the same weight. In the interim the animal must have taken in food and oxygen, and have given out carbon, nitrogen and urea; therefore, certain quantities of materials have been combined with oxygen, and have produced the same results which would have been produced in an open fire, with this only difference, that oxidation goes on slowly in the human body. For the amount of work to be done, it is immaterial how the process goes on; the amount of work is the equivalent of the chemical process or combustion performed. When an animal is reposing, heat is produced, and its quantity is equal to the quantity of food digested, or to the amount obtainable by burning that quantity of food. Experiments to prove this are difficult to make, but they have been attempted, and the results obtained are within one-tenth of absolute correctness.

If the body be not reposing, its muscular exertion is the equivalent of mechanical work. There are many different kinds of muscular work, but the greatest amount of muscular or mechanical work is performed on the treadmill, or in going up a hill, in which the whole weight of the body has repeatedly to be raised; in the latter case to ascend the declivity, in the former because the hill, so to speak, or the treadmill, is constantly going down under the feet. In ascending a hill, the respiration is greatly increased, and is far greater than arises from muscular exertion on a plain. It would appear that in such muscular action more force or energy is excited by the increased decomposition of the body than is required for the mere mechanical work performed, and that sometimes as much as four-fifths pass off in the form of heat.

So, also, electricity can be changed into mechanical work; but in this, as in all other cases, the work performed is only equivalent to the force applied. The philosophers of the last century thought that the vital principle was antagonistic to inorganic laws, and, by suspending their actions, maintained the body in life and health; but it has been reserved for the present generation to show that the same laws of physical force which are indissolubly linked and correlated in the inorganic world are also the mainspring of the wonderful actional properties of life, and that from chemical and destructive changes the source of the mechanical powers of animated beings is obtained, and which force or energy is never destroyed or obliterated, — all organic nature being, equally with inorganic, subjected to one universal conservation of force.

HEARING WITH TWO EARS.

M. Purkynie has communicated to the Bohemian Society of Sciences some interesting experiments upon the perception of sound by the ear. Two India-rubber tubes, formed at one end into a hearing trumpet, were introduced, one into each ear, and two persons spoke at the same time into the two trumpets. Some time always elapsed before it was possible to distinguish the words on either side, or even on both sides at once. When the tubes had several branches, so that more than two persons could speak at once, it was impossible to understand their words. When two tubes were united into one trumpet, the sound of the voice was heard always as if it existed inside the head, upon whatever side the person speaking was placed. By this means we might examine the relative sensibility of the two ears, for, when they differ, the sound appears to reside in the head, nearer one ear than the other. M. Purkynie thinks that the illusion in question may be explained by the structure of the auditory conduit and of other parts of the organ of hearing. With two tubes communicating with the two ears, M. Purkynie could not succeed in associating two vowels so as to hear a diphthong. But by adapting to one ear a tube with two branches, each vowel associated easily with every other, and diphthongs were heard perfectly. In the same way two sounds, such as *s* and *a*, *f* and *a*, etc., might be confounded in syllables. Two musical sounds, when heard by the tube, produced a third tone by combination, which appeared to have its seat in the inside of the head.

CHEMICAL SCIENCE.

THE DIVISIBILITY OF MATTER.

The divisibility of matter is a subject which has been frequently treated of and reasoned upon; indeed, in most works on physics or chemistry, illustrations are given of the extraordinary degree of subdivision to which bodies may be brought by mechanical means. All these illustrations have, however, stopped far short of the limit attainable by mechanical means, and indeed have been merely given to illustrate extreme subdivisions without pushing the subject to its legitimate extent. The following experimental illustration shows what infinitesimally minute quantities the natural philosopher is capable of working with and rendering evident to the senses (or rather sense, for sight alone can appreciate them), and will also show how conventional are the ordinary ideas of magnitude.

We will start with a sheet of gold leaf. This consists of metallic gold beaten out into a film of about $\frac{1}{282000}$ of an inch in thickness, measuring 3.375 inches square, and weighing about $\frac{1}{5}$ of a grain. A single square inch therefore weighs $\frac{1}{57}$ of a grain. Now, Faraday, in his beautiful researches on the relations of gold to light, has shown that it is possible by chemical means to reduce this thickness very considerably, still preserving the metallic continuity of the film. This is readily effected by breathing on a clean plate of glass and then gently placing on it a piece of gold leaf; the latter will adhere to it, and if distilled water be immediately applied at the edge of the leaf, it will pass between the glass and gold, and the latter will be perfectly stretched. Upon now draining the water out, the gold leaf will be left well extended, smooth, and adhering to the glass. If, after the water is poured off, a weak solution of cyanide of potassium be introduced beneath the gold, the latter will be gradually dissolved away, becoming thinner and thinner; but at any moment the process may be stopped, the cyanide washed away by water, and the attenuated gold film left on the glass. If, towards the end, a washing be made with alcohol, and then with alcohol containing a little varnish, the gold film will be left cemented to the glass. By this means the thickness will have become reduced to about $\frac{1}{12}$ part of what it was originally, weighing, in round numbers, about $\frac{1}{600}$ of a grain to the square inch, and being only about $\frac{1}{3000000}$ of an inch in thickness. The film in this condition, although consisting of pure gold, presents none of the ordinary appearances of the metal, being perfectly transparent, and resembling a delicate film of pale green varnish more than a dense metallic body.

Having now obtained an extremely thin film of gold upon a plate of glass (and that it is continuous and metallic has been amply proved by Faraday), let us see how far it is possible to subdivide it by mechanical means. From an examination of Nobert's test plate, it is seen that it is possible to rule lines with a diamond point on glass so close together that upwards of 90,000 of them are comprised in the space of one inch. The apparent limit of vision in the best microscopes, as tested by De la Rue, Quekett, and Ross, does not, however, reach beyond lines separated $\frac{1}{80000}$ of an inch. Let us, therefore, cut our square inch of gold on the glass plate with lines this distance apart, and crossing each other at right angles. The whole inch will, therefore, be divided into 6,400,000,000 squares, each of which is capable of being distinctly seen under adequate microscopic power. What now is the weight of each piece? The square inch of gold weighed at the commencement $\frac{1}{57}$ of a grain. By the action of cyanide of potassium it was diminished in thickness until it only weighed $\frac{1}{600}$ of a grain. This has now been cut up into 6,400,000,000 separate pieces, each of which, therefore, weighs no more than $\frac{1}{3840000000000}$ of a grain; or, in other words, a single grain of gold — a fragment about as large as a good sized pin's head — has been divided into three billion eight hundred and forty thousand million separate pieces, each distinctly visible to the eye!

The mind is quite unable to attach any definite significance to these figures without artificial assistance; but it may, perhaps, enable our readers to form some faint idea of the minuteness of the subdivision, when we state that each square bears about the same proportion to the original grain of gold that a thimbleful of water does to a building five times the size of St. Paul's. How insignificant do our ideas of great and small appear in the contemplation of such overwhelming figures as these! In the eloquent words of Dr. Nichol, "Great and little, in truth, seem in creation alike terms expressing merely relation to us, and vanish in the universe of the infinite God."

DETECTION OF 1-10,000TH OF A MILLIGRAMME OF QUINIA.

M. Flucker, of Geneva, calls attention to the fact that by means of the fluorescence of sulphate of quinia in solution we may be able to indicate the presence of this substance in most wonderfully minute quantities. "One is able," he says, "to discover through the reaction of ammonia and prussiate of potash $\frac{1}{8000}$ to $\frac{1}{10000}$ of quinia. When sulphuric acid is in excess, the fluorescence is observable if there be but $\frac{1}{100000}$ of quinia present, when you fill a common test tube with the solution, expose it to the sunlight, and hold a piece of black paper against it. At a higher dilution, the fluorescence disappears to the eye altogether, but it becomes visible at once if a pencil of rays is made to fall vertically, or even obliquely, through the tube, when the outline of the converging rays is clearly observable, when the solution of sulphate of quinia contains only $\frac{1}{200000}$ of alkaloid. Yet this reaction is so extremely acute, that by very favorable light and a careful manner of proceeding (strong magnifying tube of the utmost possible focal distance, pure white glass, and dark background), the $\frac{1}{400000}$ to $\frac{1}{500000}$ becomes visible. In this way one can absolutely discover $\frac{1}{2000}$ to $\frac{1}{4000}$ part of a milligramme of quinine. This extraordinary sensibility exceeds anything that the analysis of the alkaloids has furnished to this time, the reactions of strychnia only showing a close approach to such great acuteness.

THE NEW METAL THALLIUM.

This new metal, it will be remembered (see *Annual of Scientific Discovery*, 1862), was discovered last year by Mr. Crookes, of England, by means of the new process of spectrum analysis, in the residuum left after the combustion of sulphur for the manufacture of sulphuric acid. The name *thallium* is derived from the Greek ϑαλλὸς or Latin *thallus*, a budding twig, — a word which is frequently employed to express the beautiful green tint of young vegetation, chosen on account of the green line which it communicates to the spectrum, recalling with peculiar vividness the fresh color of early spring.

From researches undertaken by Mr. Crookes, since the first discovery of this new body, it would appear to be by no means a very rare substance, as he states that he has found it in many mineral ores from various localities. It was present in more than one-eighth of the specimens in a large collection of cupriferous pyrites from different parts of the world; he has rarely found it, however, in pyrites in which copper was absent. In most cases it is only necessary to powder a small fragment of the mineral and ignite a little of it in the flame on a moistened platinum wire, when the green line is distinctly seen in the spectroscope. Mr. Crookes thinks that in some of the large English copper, sulphur, and sulphuric-acid works, thallium is now thrown away by the hundred-weight. A slight modification of the present arrangements of the furnaces and condensing flues, or even an examination of some of the residues, would enable nearly the whole of this to be saved. Owing to the frequent occurrence of thallium in copper ores, it is very probable that this element may sometimes be present in commercial copper, and may give rise to some of the well known but unexplained differences of quality.

The following, according to Mr. Crookes, are the properties of the new metal: "In the pure state it is a heavy metal, bearing a remarkable resemblance to lead in its physical properties. Its specific gravity is, however, higher — about twelve. The freshly-scraped surface has a brilliant metallic lustre, not quite so blue in color as lead, and it tarnishes more rapidly than this latter metal. It is very soft, being readily cut with a knife and indented with the nail; it may also be hammered out and drawn into wire, but has not much tenacity in this form. It easily marks paper. The fusing point is below redness, and with care several pieces may be melted together and cast into one lump. There is, however, generally a loss in this operation, owing to its rapid oxidation. The metal itself does not appear to be sensibly volatile below a red heat. I have made no special attempts at present to determine the atomic weight, although, from two estimations of the amount of sulphur in the sulphide, it appears to be very heavy. The figures obtained did not, however, agree well enough to enable me to speak more definitely on this point than that I believe it to be above one hundred. Thallium is soluble in nitric, hydrochloric, and sulphuric acids, the former attacking it with greatest energy, with evolution of red vapors. It forms two, and probably three oxides, one of them possessing basic properties. When a tolerable quantity of thallium is held on a loop of platinum wire in a flame, it imparts to the flame a most brilliant green color, and to surrounding objects a very extraordinary appearance. If the metal could be obtained in quantity, this ready means of obtaining an intense, homogeneous green light could not fail of being applicable to some useful purpose." According to Mr. Crookes, it produces *the simplest spectrum of any known element.* Theoretical inquiries into the cause of the spectrum lines, and their relation to other constants of an element, may be facilitated now we know a metal which gives rise to luminous vibrations of only one degree of refrangibility. The remarkable simplicity of the thallium spectrum offers a strong contrast to the complicated spectra given by mercury, bismuth, and lead — the metals to which it has the most chemical resemblance.

The position of the green line does not coincide with any definite line in the solar spectrum. According to Kirchhoff's theory, we must therefore assume that thallium is not present to any great extent in the sun. Under the highest telescopic power of my apparatus, the line appears to be absolutely identical in refrangibility with a sharp, well-defined line in the barium spectrum, to which Professors Bunsen and Kirchhoff have given the name Baδ.

The spectral green line is an exquisitely delicate test for the presence of thallium, and shows it to be a somewhat widely distributed element. Many specimens of crude sulphur contain it, especially when rather dark-looking. In most cases it is only necessary to set fire to as large a piece of sulphur (less than a pea) as the platinum loop will hold, and when it has nearly burned away, to blow it out, and then introduce it at leisure into the flame of the spectroscope, for the thallium to show its presence by a bright-green line which will flash for an instant into the field of view.

A NEW METAL IN NATIVE PLATINUM.

Prof. Chandler, of Union College, in a note to *Silliman's Journal*, states that some time ago, while examining native platinum from Rogue River, Oregon, he "became convinced of the probable existence of a hitherto unobserved metal. I have deferred publishing my observations, hoping to obtain material for a more complete examination; in this I have thus far been disappointed.

"The quantity of platinum examined amounted to only a few grammes. It was digested with hydrochloric acid to remove impurities, and the solution thus obtained was subjected to the ordinary routine of qualitative analysis.

"A brown precipitate was produced by hydrosulphuric acid, which dissolved readily in hydrochloric acid on the addition of a crystal of chlorate of potassa. In this solution metallic zinc produced a precipitate which resembled metallic tin, obtained under similar circumstances. This precipitate dissolved readily in hydrochloric acid on the application of heat, but the solution thus obtained had no effect on a solution of protochloride of mercury (HgCl), and on cooling deposited a small quantity of minute crystals.

"The chloride of this metal differs, therefore, from the protochloride of tin, in not reducing protochloride of mercury to calomel, and in being but slightly soluble in the cold.

"In 1852, Dr. F. H. Genth announced the existence of a new metal, occurring among grains of platinum received from California. It was malleable; it fused readily on charcoal before the blow-pipe, becoming covered with a coating of black oxide; it dissolved in borax to a colorless bead, which became opalescent on cooling; it was dissolved by hot hydrochloric acid, and by nitric acid; and its solution gave a brown precipitate with hydrosulphuric acid. It seems quite probable, therefore, that the metal which I have observed in the Rogue River platinum is identical with that observed by Dr. Genth."

DIFFUSION OF RUBIDIUM.

M. Grandeau discovers this newly-recognized metal in coffee, tea, tobacco, grapes and crude tartar. The tobacco employed came from Kentucky and Havana. The leaves were acted upon by water, which was evaporated, and the residue calcined and tested by the method of spectrum analysis, which indicated potassium, a small quantity of lithium, and a notable proportion of rubidium. Coffee is still richer in rubidium than tobacco; but, as is the case with tea, yields no trace of lithium. He found no rubidium in colza, cocoa, and cane sugar, nor in certain kinds of fucus.

NEW INFLAMMABLE GAS.

At a recent meeting of the London Chemical Society, Dr. Hoffmann made a communication on the preparation of a spontaneously-inflammable gaseous compound of silicon and hydrogen, which possesses many points of interest. He stated that it has long been believed that silicon belongs to the same group of elements as carbon, but though the normal carburetted hydrogen, C_2H_4, has been long known, indications only of the existence of the corresponding silicon compound have been attained, and these quite recently. Berzelius pointed out long ago the existence of a body which he believed to contain hydride of silicon, — it was a solid, however, not a gas, — and will probably turn out to be the hydrated oxide of silicon, since obtained by Wöhler. It is to the latter chemist that we owe the recognition of silicuretted hydrogen. While making some experiments upon the decomposition of water, he employed a plate of metallic aluminum as the negative terminal of his battery; and was surprised to find that instead of pure hydrogen being evolved, as is usual with a platinum plate, a gas was evolved which inflamed spontaneously. Upon investigation this gas was found to be composed of hydrogen and silicum, the latter being an impurity in the aluminum plate. Since then the following plan of making this gas in abundance has been devised: Take eighty parts of fused chloride of magnesium, seventy parts of silico-fluoride of potassium, forty parts of sodium cut into small pieces, and twenty parts each of the chloride of potassium and sodium. These ingredients are mixed together dry, placed in a clay crucible, and quickly heated to redness. When the mass is fused the crucible is withdrawn from the furnace, broken, and the slag removed. This slag serves, by reason of the silicide of magnesium which it contains, for the preparation of the desired gas. It is necessary to break up the slag into fragments, and act upon them under water with strong hydrochloric acid. The gas, the composition of which seems to be Si_2H_4, is at once liberated, and may be collected over water or mercury. If a bubble of the gas be allowed to escape into the air, it bursts into flame with explosive violence, a white, hollow, cylindrical ring of smoke ascends, rotating, undulating, and widening as it goes up, and distributing, when it breaks, a multitude of fine flakes of dry silica. All the appearances noticed remind the spectator forcibly of the phosphuretted hydrogen, but there is no offensive smell produced. When the gas is left long in contact with water, the curious hydrated oxide is formed, to which we have already alluded. This substance is white, and when dried and heated in a tube scintillates just like the analogous substance obtained by the oxidation of graphite. This oxide of silicon has the formula $Si_2H_2O_5$.

ARTIFICIAL PLUMBAGO.

For some time past, Dr. Crace Calvert, F. R. S., has been engaged in experimenting upon the composition of a carboniferous substance existing in gray cast iron, or, to use a more popular definition, in producing plumbago from cast iron. The effect of his experiments has been to arrive at results which throw much light upon the chemical composition of the substance, proving it to be composed of iron, carbon, nitrogen, and silicium. The substance occupies exactly the same volume as the cast iron from which it is obtained, and is sufficiently soft to be easily penetrated by a blade. The mode of experimenting pursued by Dr. Calvert consisted in placing cubes of Staffordshire cold-blast cast iron in corked bottles, with eighty times their volume of weak solutions of the following acids: — Sulphuric, nitric, hydrochloric, acetic, oxalic, tartaric, and gallic. Besides these, phosphoric, carbonic, oleic acids, tannin, and acid peat-water, were also used. After three months of contact, he found that although the external appearance of the cubes was not changed in any of the vessels, still those in contact with the weak sulphuric, hydrochloric, and acetic acid solutions, especially the latter, had become so soft externally that the blade could penetrate three or four millimetres into the cubes. He therefore removed the solutions from the vessels, and replaced them by an equal bulk of each weak acid solution, and continued to do so every month for two years, at the end of which time the cubes in contact with the acetic acid ceased to yield iron to the acid, although they were still of the original size; they had, therefore, become transformed into the carbonaceous substance, or artificial plumbago. The action of the weak acetic acid solution Dr. Calvert found to be complete, that of the hydrochloric and sulphuric solutions nearly so, and that of the nitric much less complete, whilst the other solutions either showed no similar action, or a very slight one. To examine the chemical composition of the cubes transformed by the action of acetic acid, they were reduced to a fine powder, and well washed; the powder was then dried. The cubes of gray cast iron, which originally weighed 15.324 grammes, weighed after the two years treatment only 3.489 grammes, and their specific gravity was reduced from 7.858 to 2.751. From the figures, obtained upon careful analysis, it appears that the largest part of the nitrogen originally existing in the cast iron remains in the graphitoid substance, and only a small portion is transformed into ammonia. He has ascertained by direct experiments that it is silicium and not silica that enters into the composition of the carbonaceous mass. Like silicium, the quantity of carbon found in the carbonaceous compound does not represent the whole of the carbon preëxisting in the cast iron, as carburetted hydrogens are given off during the slow action of the acetic acid in the iron.

Though in the present state of his researches Dr. Calvert considers it would be premature to assign any definite composition to this substance, the inference is that it is composed of a sesqui ferride of iron with a nitride of silicium.

DISINTEGRATED BLACK LEAD.

A new process of preparing graphite, devised by Mr. Brodie, of Oxford, Eng., is a subject of great interest, as it affords a ready means of obtaining a chemically pure black lead, that by mechanical pressure can be aggregated into a solid mass, and employed for those purposes for which the best and most expensive plumbago has hitherto alone been applicable. The outline of the process may be thus stated: the impure plumbago is mingled with chlorate of potash, and then acted upon by a mixture of nitric and sulphuric acids; these not only give rise to the evolution of gaseous chlorine compounds, but also dissolve up and remove many of the impurities. The plumbago, thus obtained in a pure form, is washed and heated. The result of the combined mechanical and chemical action of these operations is, that the plumbago is so perfectly disintegrated as to be formed into light floculi, which are capable of being blown away by the slightest current of air. In this condition they are readily condensed into solid blocks by pressure.

ARTIFICIAL PRODUCTION OF ALCOHOL AND OTHER ORGANIC SUBSTANCES.

It is inevitable that the rapid progress of discovery should be incessantly upsetting our convictions, and disclosing the precipitation with which our limitary boundaries have been erected. Until quite recently there was no position which seemed more firmly established than that which declared the boundary between the inorganic and organic to be absolutely impassable. Although it was known that organic substances were composed of precisely the same elements as those abundantly found in inorganic substances, it was affirmed that a radical distinction existed, and defied the ingenuity of man to obliterate it. We could analyze any organic substance into its elements; but, having taken it to pieces, we could not put these elements together again, so as to reform an organic substance. The utmost we were able to achieve was to re-form organic substances by means of compounds which were either themselves organic, or were derived from the degradation of some organic matter; and the problem was, how to form an organic compound directly from inorganic elements.

In point of fact, the attempt to reform organic substance from the inorganic elements into which it had been analyzed was as idle as it would be to attempt a reconstruction of a printed sentence by throwing together the letters composing that sentence, after the type had been "distributed." The analysis is elementary; the synthesis was not elementary. You may make an elementary analysis of saltpetre — resolving this compound into oxygen, nitrogen, and potassium; but with these elements you cannot directly form saltpetre; you must unite the oxygen with the nitrogen to form nitric acid, and then unite this nitric acid with potassa, to form saltpetre — precisely as you must unite the letters into significant words, and then unite these words into a sentence.

A French chemist, M. Berthelot, succeeded a few years since in forming several organic compounds, by means of hydrocarbons; but as these hydrocarbons had themselves been obtained by the degradation of organic substances, the old problem remained unsolved; he had formed his sentence out of words, but he had not formed his words out of isolated letters. And now at last he has achieved this. It is but a modest beginning, but at any rate it proves the possibility of a direct synthesis of the inorganic into the organic; he has produced hydrocarbons by the direct union of pure hydrogen and pure carbon. M. Berthelot ascertained, in the first place, that when olefiant gas (C_4H_4) is agitated for a long time with many thousand concussions with sulphuric acid (So_3, HO), that sulphethylic acid is produced, as indicated by the following formula: — $C_4H_4+2(HO, SO_3)=C_4H_5O,SO_3,HO,SO_3$. When sulphethylic acid is heated with water, alcohol distils over, and sulphuric acid remains behind. In connection with the artificial productions of alcohol, M. Berthelot's researches on the formation of acetylene are very important, as tending still further to break down the distinction between organic and inorganic chemistry. Acetylene is one of the most permanent of the hydrocarbons; its composition is expressed by the formula C_4H_2. It is produced by the action of the induced electric spark, or by the aid of heat from olefiant gas, and is also developed by the action of heat on the hydrocarbons benzole and naphthaline. Berthelot has succeeded in preparing acetylene by the direct union of its elements, carbon and hydrogen. The carbon is first purified by the action of chlorine at a high temperature. This removes sulphur and metallic impurities in the form of volatile chlorides. The carbon thus obtained in a perfectly pure state may be submitted to the action of hydrogen, aided by the highest temperature that it is possible to obtain, but no union will take place. In the like manner the inductive spark is equally powerless to effect their union. If, however, an electric arc is caused to pass between two charcoal poles or electrodes surrounded by an atmosphere of hydrogen, union takes place as soon as the spark commences to pass. Acetylene being produced, and its production continued as long as the electric arc is maintained, the acetylene produced around the poles may be carried away by a current of hydrogen, and condensed by passing through an ammoniacal solution of protochloride of copper. In this manner it is easy to obtain large quantities of acetylene, which is readily liberated in a free state by the action of hydrochloric acid. Acetylene is very important, as it presents a basis from which other bodies may be obtained; thus Berthelot has demonstrated that by the simple addition of hydrogen it can be changed into olefiant gas, and that from olefiant gas alcohol can be formed, from alcohol ether, and thus the commencement be made of a chain of compounds, all of which have been hitherto regarded as belonging exclusively to the domain of organic chemistry.

In the Great Exhibition of last year, a bottle of alcohol thus artificially formed was exhibited.

Alcohol from Coal Gas. — "Cosmos" gives the following description of a patent taken out in France by Sieur Castex: — "In burning organic matter the smoke which is disengaged can be entirely absorbed by concentrated sulphuric acid. This sulphuric acid mingled with water, and distllled, yields alcohol. To facilitate the absorption of all the smoke of the organic matter, it is made to pass over a substance like coke, wetted with the sulphuric acid. Before sending out coal gas it may be treated according to this method."

NEW METHOD OF GENERATING CARBONIC ACID.

At a recent meeting of the Franklin Institute Mr. A. L. Fleury called attention to a new and simple apparatus for generating carbonic acid and other gases, invented by Mr. F. Ruschhaupt. The apparatus consists of a strong wooden tub or vessel, two feet high, and seventeen inches wide, having a partition near the middle. The whole inside of both partitions is lined with lead. From the upper part of the wider partition a leaden pipe leads near to the bottom of the smaller partition. A leaden vessel, perforated with holes at the bottom, is filled with carbonate of lime, marble pieces, say six pounds, and dipped, by means of a sliding rod, into the larger partition, containing about seven pounds of hydrochloric acid. The other (smaller) partition is half filled with pure water, having a glove-valve as outlet. The vessel is closed air-tight by a strongly-braced cover.

Whenever a supply of carbonic acid is desired, the lead vessel containing the marble pieces is slid into the acid, which, passing through the leaden tube, under and through the water in the next partition, to the glove valve (for the purpose of purifying the gas from any foreign matter or chlorine carried over with the carbonic acid), is, by means of suitable pipes, conveyed wherever it may be desired. When the marble, which is a chemical combination of lime with carbonic acid (56.09 lime with 43.91 carbonic acid), is dipped into the hydrochloric acid, the carbonic acid is thereby expelled, the lime combining with the chlorine to form chloride of lime, which, after all the carbonic acid is expelled, can be taken from the gas apparatus by a siphon, without taking off the cover, and may afterwards be used for the purpose of bleaching, etc.

Six pounds of marble dust and seven pounds of hydrochloric acid *will furnish about one hundred and seventy gallons of carbonic acid gas; and all this at a cost of about eighteen cents!*

There is no danger of explosion, as in the ordinary copper apparatus, because the pressure can never rise sufficiently high, and the evolution of gas can be stopped at any moment by withdrawing the sliding rod which dipped the marble into the acid. Moreover, if desired, though not imminently necessary, a safety valve, as well as a pressure-gauge, may be put on. The beautiful simplicity of the apparatus, its safety, its easy management by the most ignorant person, *and, above all, its low price*, making it accessible to all classes, are the best recommendations to the public at large.

By means of this cheap gas apparatus, lager beer can not only be kept continually fresh and impregnated with carbonic acid gas, but also, by a proper arrangement of tubes, forced up by it, fresh and sparkling, to the last drop. The same may be applied to soda water, lemonade, wine, and other beverages.

CHLORINE.

A new mode of producing chlorine is due to the researches of M. Laurens. It consists in decomposing chloride of copper by the action of heat. The operation is conducted in the following manner: Chloride of copper is prepared in the usual manner, either by dissolving oxide of copper or native carbonate of copper in hydrochloric acid, or by the double decomposition of sulphate of copper and chloride of barium. The solution of chloride of copper obtained is evaporated and submitted to crystallization, then the crystalline mass is mixed with sand and perfectly dried (probably in a reverberatory furnace). The dried mixture is introduced into retorts similar to those employed in the fabrication of gas; if these retorts are of iron, they are lined with a coating formed of a mixture of clay and carbon, to isolate the metals. The chloride, heated strongly, is decomposed into *chlorine* and protochloride. The residue of the preparation of chlorine, *i. e.*, the protochloride, is not lost. It can be again converted into chloride by the oxidizing action of the atmosphere in presence of hydrochloric acid. Having thus obtained the regenerated chloride, the operation is repeated as before described, and the circuit may be renewed indefinitely.

NEW PROCESS FOR MAKING OXYGEN.

A new and cheap process for making oxygen gas has been devised by Mr. I. Webster, of London, and a company has been organized to introduce the invention. The materials used are nitrate of soda and crude oxide of zinc, mixed together in the proportion of ten pounds of the former to twenty pounds of the latter. The ingredients, thoroughly dried, are heated in an iron retort to dull redness, when a large quantity of oxygen is speedily given off, mixed, however, with nitrogen, to the extent of forty-one per cent. The cost of the oxygen thus obtained is said to be about one-fifth of that of other processes; and it is expected that the mixed product of oxygen and nitrogen thus obtained will prove useful to augment the illuminating power of coal gas, and in various metallurgical operations.

ARTIFICIAL GEMS.

M. Becquerel has succeeded in producing opals and other crystalline minerals, in a short space of time, by strong currents of electricity. In order to succeed in these experiments, the solution must be pure, and of a particular strength, while the intensity of the current must be regulated by the nature of the materials. From a solution of sulphate of alumina he obtained, in the course of a few hours, a hydrate of alumina, like diopside, hard enough to scratch quartz. In like manner he has hopes of ultimately producing topazes and sapphires.

A recent English writer, Mr. Howgrave, thus reviews the various attempts that have been made by chemists, from time to time, to produce, by artificial means, the diamond and other precious stones. As regards the production of the diamond, but little progress has yet been made, and chemists have been completely baffled in all their efforts to find a substance capable of dissolving carbon, the chief constituent of that crystal; and, indeed, until Despretz succeeded, by the agency of electricity, in actually producing minute diamonds, the manufacture of this precious stone seemed as chimerical as that of the philosopher's stone, so perseveringly sought after by the ancient alchemists. Despretz found that by passing a powerful galvanic current through a point of charcoal over which a platinum wire was suspended, the charcoal was volatilized and deposited on the wire in the form of minute crystals, which, on examination under the microscope, proved to be true diamonds. Since the discovery, no further advance has been made toward the solution of this interesting problem.

The search after the diamond having proved so unsatisfactory in its results, attention was directed to a class of stones almost as simple in their composition, going under the generic name of *corundum*. In order to understand the experiments that were made, and the difficulties attending them, it is necessary that a clear idea should be obtained of the compositions and distinctive characteristics of the stones belonging to this class.

The ruby, sapphire, oriental topaz, and several other precious stones, are all merely colored varieties of a mineral called corundum, or white sapphire, the composition of which was stated by Chenevix to be alumina, mixed with a small proportion of silica and oxide of iron. Dr. Muir and others proved, however, that it was pure alumina, the silica found by Chenevix being abraded from the substance in which the stones were imbedded. All the varieties of corundum crystallize in six-sided prisms, and have the curious property of double refraction, that is, causing everything that is looked at through them to appear double. Alumina, the oxide of the metal aluminum, now coming into such frequent use in the manufacture of articles of jewelry, etc., was, until the invention of the oxyhydrogen blow-pipe, supposed to be, like carbon, infusible by any degree of heat. In 1837, however, M. Gaudin, who had given much attention to the effects produced by this then newly-invented means of generating heat on various metallic oxides formerly thought unsusceptible of fusion, attempted with some success to convert, by its aid, the apparently infusible alumina into crystals similar to the ruby and the other oriental stones. He proceeded by submitting to the action of the blow-pipe a mixture of alum (sulphate of alumina and of potash) and chromate of potash which he placed in a cavity of animal charcoal. In this manner he obtained small portions of melted alumina, having the color and hardness of the ruby, but which could be easily distinguished from it by their imperfect transparence, and by their not possessing the property of double refraction. All subsequent attempts to obtain crystals of alumina colored like the precious oriental stones have failed in a similar manner; and this has been accounted for by the discovery only lately that the color of these stones is not due to a metallic oxide, as had been always supposed, but to the presence of some organic coloring matter. The application of this discovery may bring us nearer than we have ever yet been to the invention of a mode of producing artificially these rare gems.

The next step in this direction was made by the manager of a manufactory of Sevres porcelain, named Ebelmen, who, ten years after M. Gaudin's experiments, found out a way of obtaining crystals of corundum, but of such minute proportions as to be of no practical use. He first discovered that boracic acid, which had been hitherto supposed to be absolutely fixed, could be evaporated by the intense heat of the porcelain ovens; upon this it occurred to him that by dissolving alumina in boracic acid, which could be done by heat, and then evaporating the liquid, it would be possible to obtain crystals resembling the oriental stones; and it was found, in fact, that by exposing a platinum capsule, containing such a mixture, to the heat of the porcelain oven for a considerable time, the boracic acid was evaporated, and a number of little shining crystals of alumina, having the properties and appearance of small precious stones, were left adhering to the capsule, but adhering so tightly that it was found impossible to detach them entire.

One other experiment is worthy of notice before proceeding to the only one which had any practical result. It is that of M. de Senarmont, who obtained similar microscopic crystals by exposing hydrate of alumina, or alumina combined with water, to a great heat, which caused the water to evaporate, and left the crystals at the bottom of the glass tubes in which the experiment was conducted.

The perseverance of M. Gaudin, who appears never to have abandoned the idea of manufacturing precious stones, enabled him, in 1857, to present to the Academy of Sciences several white sapphires, produced by a very simple process, and of sufficient size to be used as jewels in watches.

The following is the mode of procedure by which M. Gaudin succeeded in producing these crystals: —

In a crucible, lined with animal charcoal, are placed equal parts of alum and sulphate of potash, previously calcined to expel the water. With this mixture the crucible is half filled; it is then filled up to the top with animal charcoal; the lid is put on and cemented in its place with clay, and it is then exposed in a furnace, and kept at a white heat for a quarter of an hour. The heat and the reducing power of the charcoal cause the formation of sulphuret of potassium, which fuses and dissolves the alumina. The continued action of heat partly evaporates this sulphuret of potassium, and the alumina separates in the form of little crystals. On opening the crucible, a black mass, sparkling with brilliant points, is found in it, which consists of sulphuret of potassium, mixed with crystals of alumina. This mass is afterward placed in diluted nitro-hydrochloric acid, which dissolves the sulphuret, and lets fall the crystals of alumina to the bottom of the vessel, where they appear as a coarse powder, and, seen through a microscope, have an exact resemblance in form to the natural precious stones. By using a larger crucible, and exposing it to the action of the fire for a longer period, M. Gaudin produced crystals of much greater dimensions, which, upon examination, proved to be true white sapphires, and were even superior in hardness to the rubies ordinarily used for the jewelling of watches. He endeavored to produce colored crystals by the addition of metallic oxides, but found that these were invariably reduced into metals by the action of the charcoal. The successful result of this experiment encourages us to hope that at a future period M. Gaudin, or some one else possessed of his indomitable perseverance, may discover some substance capable of dissolving carbon in a similar manner to that in which sulphuret of potassium has been found to dissolve alumina, by which the problem of the artificial production of that beautiful and valuable stone, the diamond, will at length be solved.

Although not belonging strictly to the subject of the artificial production of precious stones, it will not, perhaps, be thought inappropriate to notice some experiments undertaken by Messrs. Deville and Wöhler, which resulted in the discovery of a crystal strongly resembling the diamond in its hardness and properties, although of a different composition. This crystal is that of a substance called boron, which attracted the attention of Messrs. Deville and Wöhler, on account of its resemblance to carbon. It occurred to these gentlemen that a substance having such a great similarity to the element of which the diamond is composed, would, in all probability, if crystallized, have some characteristics in common with that gem. They therefore set to work to find some process which would enable them to reduce it to the crystalline form.

Boron is only found in nature in combination with oxygen, as boracic acid, and in union with soda, as borax; and it had, up to this time, been obtained from these combinations only in the form of a brownish green powder, insoluble in water, possessing many of the properties of carbon. It was reserved for the two chemists whose names are given above to produce it in a form hitherto unknown, by the following process: —

In a crucible, lined with animal charcoal, are placed eighty grains of aluminum, and one hundred grains of boracic acid. This crucible is then exposed for five hours to an intense heat, which causes a portion of the boracic acid to part with its oxygen to the aluminum. After it has been taken from the furnace and allowed to cool, it is found to contain a sort of glass composed of the remainder of the boracic acid and of the alumina formed during the process of heating, and underneath this a gray metallic mass, sparkling with crystals. This mass consists of merely boron imbedded in aluminum. To separate the boron, the mass is plunged into boiling caustic soda, which dissolves the aluminum, and is afterward treated with hydrochloric acid, to remove all traces of iron, and with a mixture of nitric and hydrofluoric acids, to get rid of any silicon that may have been left by the soda. After all these processes have been gone through, the boron remains alone.

An examination of the boron obtained in this way shows that a great analogy exists between it and carbon, which, as every one knows, is found in three forms: uncrystallized in charcoal; semi-crystallized in plumbago; and crystallized in the diamond. Similarly, the boron resulting from the above experiment is found to exist in three forms, namely, in black flakes almost as hard as the diamond; in brilliant prismatic crystals, less hard than the former variety; and in small, beautifully-formed reddish crystals, having a great resemblance to the diamond. These crystals are as hard as the diamond itself, and may, in the course of time, should their manufacture be brought to perfection, supersede that stone in many of its uses, such as cutting and polishing precious stones, forming jewels in watches, etc.; and thus, although, from their being unknown in nature, they cannot be considered precious stones, the discovery of these boron diamonds may prove of more practical value than all the attempts at the artificial production of the real diamond.

THE ANNEALING TEMPERATURE OF METALS.

The "annealing temperature" has not yet been ascertained for any one metal, and all that is known about it is, that there is a fixed and rather narrow range of elevated temperature peculiar to each metal, without the limits of which annealing does not take place, and that the absolute mean temperature for each metal seems to be greater in some proportion as the fusing temperature of the metal itself is higher. Platina, for instance, when hard from wire-drawing or lamination, is not annealed under an intense white heat; wrought iron at about a bright red, in some sorts not before a yellow heat; copper, at a low cherry-red; and when we come down to the metals of very ready fusibility, such as tin and lead, their annealing temperature appears to be so low that the *heat evolved* in them by conversion of mechanical force in laminating or wire-drawing is sufficient to keep them annealed, that is, they *cannot be hardened* by such processes. It is this curious fact of molecular physics which affords the explanation of the circumstance, well known to those engaged in the trades of rolling sheet lead, or "drawing" lead pipes by the older methods, namely, that the rolling or drawing can be accomplished by a *less total expenditure of power* if performed fast than much more slowly. That is to say, the power demanded is a minimum when the pressure is sufficiently sharp to evolve the heat of annealing in the lead. Upon a like condition (with others not here in question) depends the curious process of forcing up in pure tin the patent collapsible vessels of Rand, now so extensively in use for receptacles of oil-colors, perfumes, etc.—*Journal of the Franklin Institute.*

ARTIFICIAL STONE.

The following is an abstract of a paper on the above subject, communicated to the British Association, in 1862, by Prof. Anstead:— My object in the present communication is to direct the attention of the section to the different classes of the material that have been found available; to point out the principles involved in each, and the special advantage and disadvantage each possesses; to refer to a new and I believe an important material; and to suggest the bearing of the whole subject on that of the preservation of stone from decay.

The artificial stones hitherto used may be grouped under one of three heads. They are either (1) terra cotta, or manufactures of plastic clay burnt in a kiln; (2) cements manufactured from a certain kind of limestone containing foreign ingredients of such a nature, that, when converted into lime by burning, the lime thus made possesses the property of setting very rapidly and firmly when wetted; (3) silicious stone, obtained by burning in a kiln, sand, and other substances, moulded with a solution of silicate of soda, which is converted into a kind of glass, firmly connecting the particles. I omit plasters, as rarely exposed to the weather.

Terra Cotta.—The advantages of this material are, (1) its cheapness and the universal distribution of the clays of which it can be made; (2) the facility with which it can be moulded to any required form; and (3) the pleasant color of the material when uninjured by long exposure to weather. The disadvantages of terra cotta are, (1) the uncertainty of the result, owing to the great and unequal contraction of all clays in burning; (2) its want of power to resist damp and frost whenever there is the slightest flaw, whether produced before or after burning; (3) its brittleness and want of strength; (4) its exposure to a disagreeable green vegetation in damp air after a few years' weathering. Terra cottas are better adapted to a dry than a moist climate.

Cement. — Whether of the kind called Pozzuolana, Roman, or Parker's, or Atkinson's, or any modification of these, all the cements are similar in their nature. The advantages of cements used as an artificial stone are, (1) its cheapness when made, and its ready transport; (2) its not requiring the kiln, but setting at once without contraction; (3) the facility of moulding, and in making up the material from the manufactured cement supplied; (4) its great strength when well made. The disadvantages are, (1) that it cracks and peels badly when exposed to frost and damp air; (2) that it is very irregular, some samples yielding a much harder, better, and more lasting stone than others, without apparent reason; (3) that it is subject to a green vegetation, like terra cotta. These disadvantages do not all apply to its use in making concrete, for which it is admirably adapted.

Silicious Stone. — This product, known in England as Ransome's, is extensively used. The advantages are, (1) the extreme uniformity of its texture; (2) the almost entire absence of contraction, and its freedom from cracks and flaws produced during burning; (3) its complete resistance to all kinds of weathering, to which may be added (4) its pleasing color and tint.

On the other hand, among the disadvantages are, (1) its cost, which is greater than for either of the other kinds of artificial stone; (2) its being subject to a white efflorescence of salt and a green stain from damp, both of which take away from its value for ornamental purposes, for which it is otherwise admirably adapted.

The mechanical and chemical principles involved in these different contrivances are as follows: in terra cotta the material is a kind of clay, purer and more free from foreign substances than common clay, and mixed with dust from pottery already made. The manufactured article is thus a superior fire brick. The burning produces little chemical change or metamorphosis, but the condition after burning is so far different that ordinary exposure will not bring back the original texture of clay. Of closer texture than brick, there is less absorption from the surface; but in ornamental work there are always flaws enough to render frost following rain dangerous and injurious. In other respects the material itself is little more liable than brick to injury from exposure.

In cement the raw material is carbonate of lime, with a certain but variable proportion of foreign substances, of which clay or silicate of alumina is an important and even an essential part. All the varieties of cement stone, such as the stones called septaria and other nodules, agree in this. On burning this material the limestone is converted into lime, and the condition and proportion of the foreign material determines the value of the resulting cement. It is called hydraulic cement, as setting with almost any required rapidity when properly mixed with water, and this in damp air, during rainy weather, and even under water, absorbing no more water than is necessary for consolidation. Under various names, pozzuolana, Roman cement, Parker's cement, Atkinson's cement, etc., this valuable material has been used from time immemorial, and is especially adapted for making concrete where a larger proportion of foreign substances is introduced. As an artificial stone, although it hardens on exposure, its composition is too irregular to justify a very extended use. In the process of setting the lime first mixes with water and becomes hydrate of lime, and is then rapidly converted into silicate of lime, adhering strongly in thin films to itself and to foreign bodies with which it is in contact.

The silicious stone of Mr. Ransome consists of sand and foreign substances, worked up into a paste with the fluid silicate of soda. If left to dry in the air it would fall to powder, but being exposed to a high heat in a kiln a chemical action takes place. The alkali of the silicate of soda "combines with an additional quantity of silica supplied by the sand, etc., with which it is incorporated, and becomes converted into an insoluble glass, firmly agglutinating all the various particles together into a solid, compact substance." No sensible contraction takes place in burning, and cracks rarely occur.

The resistance to weather offered by these three kinds of artificial stone may be thus stated: 1. Terra cotta, contracting irregularly in the kiln, is subject to cracks and flaws, into which water penetrating and expanding during frost, a peeling and splitting of the material naturally follows. It is almost certain, from the nature of the case, that delicate and ornamental work should be more liable to such injury than straight work and plain surfaces. 2. Cement, owing to the want of homogeneity in the raw material, is also very subject to flaws and cracks, and is injured by damp and frost like terra cotta. 3. The silicious stone is rarely flawed in the kiln, but even if it is the stone does not crack or the surface peel by exposure to damp and frost, owing to the nature of the cement, which is, in fact, glass.

A new process, however, has been recently discovered by Mr. Ransome, which promises most valuable results. Heretofore, his artificial stone, after its formation in a plastic state, required about one month to dry, and another to be kiln-burnt. Now, it seems, the plasticity is superseded by stony hardness not only without either drying or kiln-burning, but also in an hour or two's time! The moulded or prepared stone requires simply to be dipped into a solution, and the work is done, even when the stone has been one weighing a whole ton weight or more. The solution consists of chloride of calcium; or, as it is more properly called when dissolved in water, muriate of lime. When the moulded matter is dipped into this solution it is very soon saturated with it, and a double decomposition takes place; the lime combines with the silica, forming a silicate of lime, and the muriatic acid with the soda of the water-glass, forming common salt, which can be removed by washing. To prove that by this process a coating of hard silicate of lime is actually formed, Mr. Ransome, in a public experiment, made small blocks of various forms, in moulds, by mixing loose sand with the fluid silicate of soda, and then dipping the mould into the chloride of calcium; when there came out almost instantaneously a perfectly compact, hard, and, to all appearance, a perfectly durable solid. The stone thus formed has already been tried on a somewhat extensive scale, and found to answer all requirements. At the Great Exhibition of 1862, a mass of it, weighing ten tons, formed the bed of a steam-engine; and a four-inch cube has been found to sustain a weight of thirty tons before crushing.

At the meeting of the British Association, in 1862, Mr. Ransome, at the conclusion of Prof. Ansted's remarks, manufactured the stone in the presence of the audience. It consists of any kind of mineral fragments, sand, limestone, or clay, mixed into paste with fluid silicate of soda (obtained by digesting flints in a boiler under high pressure in alkali), and afterwards dipped into a solution of chloride of calcium. The result is an almost immediate hardening of the pasty mass, and the specimens constructed were in a few minutes handed about the room.

In a paper on the preservation of stone, recently read before the London Architectural Association, Mr. A. H. Church noticed the curious effect produced on stones by the efflorescence of sulphate of soda or sulphate of magnesia upon their surface. The formation of such salts is actually favored by some of the so-called preservative processes; and it is remarkable to note upon the summit of each hair-like crystal a minute fragment of stone torn off and carried forward by the force of the crystallization. Another singular phenomenon was described as occurring when a strong solution of silica in water is applied to chalk or any soft limestone. The silica glutinizes on the surface; the film thus formed separates into small scales, and as these fall off, it will be noticed that their under surfaces are covered with minute adherent particles of the stone or chalk.

THE DISINTEGRATION OF BUILDING STONES.

Prof. Thomson, in a paper before the British Association, 1862, showed, first, that the crumbling away of stones in buildings usually occurs in the greatest degree at places to which, by the joint agency of moisture and evaporation, nitrates and other salts are brought and left to crystallize; secondly, that the solidification of crystalline matter in porous stones, whether that be ice formed by freezing from water or crystals of salts formed from their solutions, usually produces a disintegration, not, as has been commonly supposed, by expansion of the total volume of the liquid with the crystals during the growth of the crystals, producing a fluid pressure in the pores; but, on the contrary, by a tendency of growing crystals to increase in size even where to do so they must push out of their way the porous walls of the cavities in which they are contained, and even though it be from these walls that they receive the materials for their increase.

CHEMICAL MEMORANDA.

Improvements in Matches. — In the place of sulphur for coating matches, — thereby rendering the wood more inflammable, — an English company have introduced paraffine; and matches thus prepared are not likely by the vapors they generate to tarnish silver surfaces and dyed fabrics. Paraffine matches are found to withstand dampness in a most remarkable manner.

Amorphous Phosphorus and its Practical Applications. — The discovery that phosphorus is capable of existing in a condition in which it is no longer spontaneously inflammable has been turned to account in the manufacture of matches, which cannot be ignited by friction anywhere except on the prepared surface of the box which contains them. The secret of the contrivance is, that the chlorate of potash compound, tipping the match, is destitute of phosphorus, which in the amorphous form is placed on the sand-paper; hence these matches are perfectly safe from accidental ignition, and moreover are not poisonous.

Comparative Fusibility of Iron. — MM. Minary and Résal state that the fusibility of iron augments with the proportion of oxygen which it contains: thus, in placing side by side, in a blast furnace, two crucibles containing iron shavings of the best quality, but adding to the second a certain proportion of oxide of iron, after exposure to a hot blast the fragments in the first crucible preserved their original condition except that they were slightly welded together, while those in the second were fused into a lamellated button. — *Comptes Rendus.*

Phosphorized Copper and Brass. — The peculiar effects of the presence of small portions of phosphorus on the properties of metallic copper have been studied carefully by Mr. Parkes, of England, who has taken out a patent for the application of phosphorus to the improvement of the working properties of metallic copper. Phosphorized copper, as it is termed, possesses an extreme degree of malleability, and may be forged readily even when heated to redness; it is so ductile that it is capable of being drawn out into tubes, which can be flattened in various directions, or even tied into close knots, without showing any evidence of cracking; these tubes are made, in the first instance, by casting them of a large size, and the diameter is then reduced by drawing them in the same manner as wire. The extreme ductility of phosphorized copper is shown by the production of a long tube with a bore as fine as a needle, which has been reduced down by drawing from a nine-inch casting. Brass manufactured from phosphorized copper also retains many of its valuable properties.

New Alloy; a Substitute for Silver. — The Paris *Cosmos* describes a new alloy composed of block tin three hundred and seventy-five parts, nickel fifty-five, regulus of antimony fifty, and bismuth twenty parts, which M. Trabuc, of Nismes, proposes as a substitute for silver, as it resists the action of vegetable acids. It is prepared by placing in a crucible one-third of the tin, together with the nickel, antimony, and bismuth; over this is laid another third of the tin, and above that a layer of charcoal. The crucible is then closed and brought to a reddish-white heat, and its contents examined with a red-hot rod of iron to ascertain if the nickel is melted and the antimony reduced. The last portion of tin is then made to pass through the charcoal, and the mixture well agitated.

Food Preservative. — A patent has been recently granted in England for preserving articles of food by introducing into tin cans containing the food a substance for which oxygen has a greater affinity than for the meat or other article of food under preservation, and which at the same time shall be in no way detrimental to it. Such an agent, the patentees state, is sulphate of soda.

Reduction of Chromium and Manganese. — In the course of some experiments with amalgam of sodium, the idea occurred to Mr. C. W. Vincent that it might be employed to advantage as a ready means of reducing some of those metals which are not readily obtained by ordinary metallurgical processes. By adding to a solution of the chloride of chromium an amalgam of sodium, he found that, although there is a considerable waste of sodium, nevertheless an amalgam remains of chromium, which, on distillation in a tube retort filled with naphtha vapor, yields this metal in a finely-divided state. Mr. W. B. Giles has shown, in a note in the *Philosophical Magazine*, that when an amalgam of sodium is placed in a saturated solution of pure protochloride of manganese a rapid action takes place, hydrogen is evolved, and, finally, an amalgam of manganese remains. For the details of the experiment which led Mr. Giles to infer that the powder which he obtains is metallic manganese, we must refer to his note. He states that the same results appear to take place with cobalt.

Coloration of Iron. — M. Thirault, pharmaceutist of St. Etienne, has been investigating the natural oxides of iron. In addition to ordinary rust, there is another oxide (the ferrosoferric oxide) but slightly susceptible of alteration. Iron covered with this latter is protected from rust even in moist air. This varnish is produced by the use of the following mixtures: 1. Chloride of mercury and sal-ammoniac. 2. Perchloride of iron, sulphate of copper, nitric acid, alcohol, and water. 3. Per- and protochloride of iron, alcohol, and water. 4. Weak solution of sulphide of potassium. These solutions are successively, and after the previous application has become dry, applied. No. 3 is applied twice. A bath of boiling water follows Nos. 3 and 4. The shade of color is fixed by means of active friction by a piece of woollen goods, and with a little oil. The shade of color imparted is of a beautiful black, uniform in appearance. This process is used in the manufacture of arms at St. Etienne.

Copper Paint. — The Paris *Cosmos* calls attention to a new pigment recently brought into use in France. Its foundation depends upon the possibility of reducing electrolytic copper to an impalpable powder, which, being combined with benzine, can be employed upon any surface as a paint. It possesses an agreeable lustre, and will take bronze tints by the usual chemical means. By reducing the quantity of copper, and adding bases of lead, zinc, or other metals, M. Oudry obtains a series of paints said to possess great advantages over those prepared with turpentine and ordinary oils.

Utilization of waste Tin Plate. — A process is now in use in Austria, discovered by M. Kuhn, a German chemist, by which the tin from the useless scraps of tinned iron plate is obtained in the pure form. It is stated by the discoverer that the labor of four men can produce yearly, from perfectly valueless tin cuttings, three hundred weight of pure tin, with a large proportion of malleable iron and other products.

Experiments on Solubility. — M. Gay-Lussac has ascertained that the " solubility of a body is not modified when it passes from the solid to the liquid state." The converse of this proposition is also affirmed, that is to say, " that the presence of a solvent does not modify the fusing temperature of a body if no chemical action takes place." Thus, if finely divided sulphur is suspended in sulphuric acid, bichloride of tin, and amylic alcohol, which are three of its solvents, it is seen to enter into fusion (be dissolved) in the three liquids exactly at the same temperature of 111.5° Cent. Phosphorus enters into fusion at 44° Cent. in water, the various alcohols, chloroform, bichloride of tin, etc. Similar observations have been made with iodine, and various fatty bodies, always with similar results.

Secrets in Glass Manufacture. — It would appear that there are yet some secrets in relation to the manufacture of glass, unknown to the world at large, as the manufactory of M. Daguet of Soleure, France, is known to be in the possession of an undivulged method which enables them to make glass of a purity which all other manufacturers are not able to rival. A railway, recently constructed, and running past M. Daguet's works, has, however, so affected the glass pots, by the tremor occasioned by the locomotives and trains, that work has had to be suspended. For this M. Daguet brought action during the past year against the railway company for damages, but when the case came on for trial the court held that it would be impossible to assess the damages, unless it were made cognizant of the secret, and its pecuniary advantage to M. Daguet. The latter declined imparting this, and the court refused to proceed further.

Painting with Aniline Colors. — The *American Journal of Photography* states that aniline colors may be used for painting albumen photographs. These colors are all soluble in alcohol, and, being thickened with the proper spirit varnish, are equally suitable for painting transparencies on glass for the magic lantern and other purposes. There are no colors more dazzlingly bright than the aniline dyes, and they are as permanent as any others of a similar tint.

Coagulation of the Blood. — At the last meeting of the British Association, Dr. Davy detailed a large number of experiments made to test the hypothesis brought forward by Dr. Richardson, that the coagulation of the blood mainly depends on the escape of ammonia. The many results described by the author were opposed to this view. First he showed that blood in its healthiest state contains no appreciable quantity of the volatile alkali; and, secondly, that ammonia added to the blood in a notable quantity did not arrest the change. The conclusion finally arrived at was that we are yet ignorant of the cause of the phenomenon, and that the hypothesis of Dr. Richardson if acted on in medical practice must be attended with risk.

A new Drop-Counting Apparatus, invented by M. Salleron, is figured and described in the *Repertoire de Chimie*, accompanied by a table giving the names of liquids at the temperature of plus fifteen degrees Cent., the weight of one drop of each in grammes, the number of drops equal to one gramme, and the weight of twenty drops. The apparatus is composed of a small flask, with a side tube, by which the liquid is poured out. The diameter of the spout from which the liquid falls drop by drop is determined for the weight of a drop of distilled water, — *i. e.* five centigrammes. Twenty drops of water thus collected weigh then exactly one gramme; and this exactness, it is said, is so great that these twenty drops always give the same weight, if care be taken to dry the external edges of the tube every time that the liquid is made to flow. The form and capacity of the flask may vary, but not the diameter of the exterior side tube, which constitutes a true and precise instrument. We give a few results: The number of drops of distilled water for a gramme being 20, the number for the same weight of nitric acid will be 27; of sulphuric ether, 90; of laudanum, 34; of chloroform, 60; of tincture of rhubarb, 54, etc.

Healthfulness of fresh Paint in Apartments. — M. Leclerc, a well-known house-painter in Paris, has made several experiments to ascertain whether emanations from certain paints containing such substances as white lead, zinc white, linseed oil, essence of turpentine, coal oil, essence of lavender, etc., are injurious to health. He caused the inside of some boxes to be painted, and within them he placed wire cages containing rabbits, which were not in contact with the paint, but only subject to the influence of the emanations from it. The rabbits suffered while the paint was fresh, especially when it contained coal oil, but none of them died. It is thus proved that living in apartments recently painted, and which emit the odor of the oil of turpentine, is not permanently injurious to health. M. Leclerc made, also, some other experiments, for the purpose of obtaining deposits of these emanations from the fresh paintings of houses. Instead of rabbits he placed plates containing a small quantity of water in these chests. After the water had evaporated from the plates he found some remarkable crystallizations like needles, which consisted of combinations in which the oils or essences employed formed the principal part. These crystalline combinations were obtained even when linseed oil was used.

The Capillary Attraction of Paper has been employed by M. Schönbein in chemical analysis. He employs in his researches leaves of unsized white paper, suspended at right angles above the surface of the liquid. They are plunged into the liquor to the depth of two or three millimetres, and remain so till the liquor rises to the height of three centimetres. M. Schönbein's experiments show that alkaline, acid, and saline solutions have different degrees of action. For example, potash, iodide of potassium, and water, are imbibed with different degrees of rapidity. The water rises before the others; the iodide of potassium follows, and the potash comes last.

Vapors of Saline Solutions. — It is known that a saturated solution of salt in water boils at 228° Fah., while pure water boils at 212; but Rudberg says that the vapors of saline solutions under the ordinary pressure of the atmosphere have only the temperature that they would possess if they were disengaged from pure water under the same pressure.

New Frigorific Mixture. — Reissig recommends a mixture of sulphocyanide of potassium and snow or powdered ice, which will produce a reduction of temperature to thirty-five degrees below zero, Fahrenheit. The salt is always recovered by evaporation.

Chloride of Lime as an Insecticide. — *Dingler's Polytechnisches Journal* says: By scattering chloride of lime on a plank in a stable, all kinds of flies, but more especially biting flies, were quickly got rid of. Sprinkling beds of vegetables with even a weak solution of this salt effectually preserves them from caterpillars, butterflies, slugs, etc. It has the same effect when sprinkled on the foliage of fruit trees. A paste of one part of powdered chloride of lime, and one-half part of some fatty matter, placed in a narrow band round the trunk of the tree, prevents insects from creeping up it. It has ever been noticed that rats and mice quit places in which a certain quantity of chloride of lime has been spread.

Soapstone Powder as a Lubricator. — Soapstone powder, in the form of dust, is proposed as a lubricant for the axles of machines. For this purpose it is prepared as follows: It is first reduced to the condition of very fine powder; then it is washed to remove all gritty particles; then it is steeped for a short period in dilute muriatic acid (about one quart of acid to twenty of water), in which it is stirred until all particles of iron which it contains are dissolved. The powder is then washed in pure water again to remove all traces of acid, then it is dried, and is the purified steatite powder used for lubrication. It is not used alone, but is mixed with oils and fats, in the proportion of about thirty-five per cent. of the powder added to paraffine, rape, or other oil. This steatite powder mixed with any of the soapy compounds which are also now used in many cases for lubrication also answers a good purpose. It is chiefly intended for heavy machinery, such as the journals of water-wheels, railway and other carriages.

WINES—THEIR COST AND QUALITIES.

In 1861 the British government instituted an inquiry into the "strengths of wines in the principal wine-growing countries of Europe." It embraced the growths of France and Switzerland; of the Rhine provinces, Bavaria, Hungary, and Austria; of Spain and Portugal; of Sicily and Italy. The gentlemen selected for this mission were eminently qualified for the task, and have executed it with diligence and judgment. Though their instructions were specially to ascertain the percentage of alcohol contained in the various products of the grape, their researches were necessarily of a much more expanded character. Mr. Ogilvie, inspector-general of customs in London, reported on France and Switzerland. At the commencement of his remarks he observes that he confined himself to those wines known to contain in their natural condition the greatest quantity of spirit. His inquiries, therefore, were limited to the south-eastern and southern districts of France, commencing in the Burgundy district, and extending as far south as Perpignan, at the foot of the Pyrenees, and thence back to Bordeaux.

The quantity of wine produced in France from year to year varies considerably, being seriously affected by the weather and other circumstances. Of this uncertainty in the crop the following statement is ample proof: "In 1847 the produce was upwards of 54,000,000 hectolitres, or 1,011,188,000 gallons; but in 1854, owing to the disease that made such ravages among the produce of the vines throughout Europe, the total production dropped below 11,000,000 hectolitres, or 242,000,000 gallons, being about one-fifth of the former year." Independently of the oidium, or the vine disease, which may be regarded as exceptional, severe frosts in the early part of the year kill the plants in low-lying localities, while abundant rains in summer render the juice of the grape inferior through weakness. It may be well here to observe that the hectare is equal to two and a half English acres, and the hectolitre to twenty-two English gallons. If the aggregate crop is liable to very great fluctuations, so is the proportionate quantity in different localities. Thus, in 1861, according to Mr. Ogilvie, the produce in the department of the Jura was estimated at 6½ hectolitres per hectare, or about 57 gallons per acre; on the other side of France, in the Charente Inférieure, it was estimated at 10 hectolitres per hectare, or 88 gallons per acre; while in some parts the produce was computed to have reached 60 hectolitres per hectare. In 1858, the total production of France averaged 25 hectolitres per hectare, or about 220 gallons per acre; in the following year it was only about 14 hectolitres per hectare, or 123 gallons per acre. From this uncertainty of production prices must be subject to excessive fluctuation, which is only to be guarded against by the culture of a larger area of soil. This has become the more urgent as the prices for home consumption in France itself have increased considerably during the past few years; in consequence, distillation from wine has been entirely abandoned. Still, though wine in many places is double what it was ten or twelve years ago, and in some parts even fourfold, yet it still ranges at a low figure when consumed in the district where it is made. Ordinary wine of good quality may still be obtained, under such conditions, at from 6d. to 1s. 6d. per gallon, or from 1d. to 3d. per bottle; while in the valley of the Rhone it may be had from 4s. 6d. to 12s. per gallon, or from 9d. to 2s. per bottle. Ordinary Medoc costs from 5d. to 6d. per bottle. It must be understood that these are the prices on the spot, and even without the casks or vessels containing the wine, and that what is consumed in the locality of growth is exempt from taxation. These prices are not charged with carriage or freight, or the profits on the transfer of the article from the proprietor of the vineyard to the retailer or wine merchant.

The natural strength of wine, or the quantity of spirit eliminated by natural causes, is the effect of the decomposition of the sugar contained in the grape, while the formation of sugar in the grape is that chemical process which is called "ripening." As the saccharine qualities of the grape mature the watery particles of the juice evaporate. This mutation mainly depends on climate and soil. In northern and western France the wines, as a rule, are light and inferior, and their natural strength varies from 12 to 16 per cent. of proof spirit; nor do the finest of the Bordeaux wines exceed that. Of course there are variations from year to year. Thus, in 1858, the percentage of proof spirit in Château-Laffitte, the finest of Bordeaux qualities, was 16.5; in 1859, 17.7, and in 1860, 14.8. It thus appears that wines commercially the finest and most valuable, as Laffitte, Langoa, and Palmer, are not always the most alcoholic. It is from Dijon to the Pyrenees, and on the sides of the mountain ranges at the feet of which flow the Saone, Rhone, and the Mediterranean, that the wine grows most abundantly and luxuriantly, and possesses the greatest strength, for there the summer heat is nearly tropical, especially in the southern extremity of the eastern Pyrenees. There Roussillon is produced, the strongest of all the French wines. It averages 27.9. Chambertin and Clos-Vougeot belong to the Côtes d'Or, in the eastern centre of France. Their strength is 20.8. The wines of the Côtes du Rhône, chiefly known in England as Hermitage, have a strength of 22. To the north-west of the mouths of the Rhone, in the department of the Gard, the wines known as St. Gilles are 27 per cent. proof spirit.

In Switzerland all the wine is inferior and unsuited to the English market. It is made for home consumption, and, no doubt, is grateful to an accustomed palate. It is mostly made about Neufchatel. In many places around Geneva the grape is grown to be sold as fruit. Between Neufchatel and the Jura the Burgundy wines have been planted, but they yield a wine deficient both in flavor and strength.

We pass to the vintages of the Rhine provinces, Bavaria, Hungary, and Austria. This report is by Mr. Douglas, assistant surveyor to the London Customs. The British consul, Mr. Roch, having informed him that the wines of the Moselle and of the left bank of the Rhine were inferior in strength, he travelled to the right bank, to Rudesheim, the country of the best Rhine wines. There it is the custom to keep the wines in large casks of 120 gallons; samples are given in glasses to be tasted, but not to be removed from the premises; nor are single casks readily to be obtained, the rule being for the proprietors to sell in large quantities to the merchants, as they object to comparisons between similar wines. The famous "Johannisberg" is very scarce, and cannot be classed as a wine of commerce, though it may be obtained as a favor for £1 per bottle. In the Rhenish provinces the grapes of each district are carefully kept separate, so that the produce of each vineyard forms a wine by itself without any admixture; nor is any adulteration practised, each grower or maker priding himself on the purity of his stock. The dealers, however, are not so honorable or scrupulous, but make use of all the resources of chemistry for spurious manufacture. For this fraud the town of Bingen is said to be notorious.

Rhenish wines of low quality are largely exported to the United States, the demand being for the Germans settled there. Among the most potent wines are those of Bavaria, of which the king of that country holds vast quantities, lodged in his palace at Wurzburg. It is all pure. At Pesth there are vast collections of Hungarian wines, which are almost endless in their varieties. The strongest are those of Buda, on the side of the Danube opposite Pesth, of Szexard, Arad, and Veszprim. The famed Tokay is rarely to be obtained pure.

There are enumerated from seven to eight hundred varieties of Hungarian wine, and they are generally so strong that they would be damaged with any addition of alcohol. That which is pure will keep for twenty years without change of character or color, and unfortified wine has been sent to America without suffering any deterioration. But this pure wine is unknown to England as an article of commerce, all that has arrived having been adulterated by the dealers through whose hands it has passed, under the hypocritical pretence of adapting it to the English taste. Pure wines, direct from the growers, could be sold in London, in bond, for four shillings a gallon. The average production is estimated at 400,000,000 gallons, of which at least one-third is available for export. As the supply is greater than the demand, much is distilled or made into vinegar, or even thrown away to set free the casks required for new wine. Mr. Douglas does not enter into any detail of wines strictly Austrian, not mentioning either their growth or quantity, though he specifies their strength, which varies from 17.1, as Kerschbacher, to 23.3, as Gumholdskirchner. The strength of Rudesheimer is from 20.2 to 22.7; of Hock, from 21.4 to 22. These belong to the Rhenish provinces. The Bavarian wines vary in strength from 20.8 to 22, while the Hungarian range from 19.9 to 28.6. The strongest are from Arad.

Mr. C. Bernard, of her Majesty's Customs, London, reported on Spain and Portugal. The large shippers and vineyard proprietors of those countries have for a long time been rather manufacturers than producers of wine. Hence their beverages are rather described as intoxicating than exhilarating, and the practice is justified on the ground — the correctness of which, however, is disputed — that the natural wine would gradually become unsound unless fortified by alcohol for exportation. It is ascertained that the best wines have so high a natural strength that adulteration seems quite unnecessary. We subjoin the natural ranges of the best qualities: St. Lucas, 27.0 per cent.; Xeres, 27.2; St. May's, 32.3; Montilla, 31.7. This is the process. "No spirit is added to the 'must' during the process of manufacture or pressing the grape at the vineyard, unless it is intended to be made 'sweet wine,' and then six arobas (equal to about 21 gallons of spirit, about 60 per cent. over proof) are added, in order to prevent fermentation and to retain its sweetness; and when this sweet wine is drawn off the lees, about six months after it is made, three or four gallons more of spirit are added, making in all 24 or 25 gallons of spirit to the butt." The chief use to which this sweet wine is applied is the adulteration of other wines for the English market, giving them body, flavor, and strength.

The term "Soleres" denotes old mother wines infused into the newer. The famous Amontillado is a "chance wine;" because, out of fifty butts, only two or three can be counted upon, though the grapes are gathered from the same vineyard. The wines of Valencia, Benicarlo, and Alicante, are passed off as Ports; and to aid the fraud, the casks are so constructed in size and appearance as to deceive the inexperienced. There is no such article as standard sherry.

At Lisbon wine is excessively fortified. A natural sample of the quality selected by Mr. Bernard gave 25.9 per cent.; another, to which ten gallons of spirit were added, gave 33.3. It appears, indeed, that the Alto Douro wines, the finest in Portugal, require some 20 per cent. of extraneous spirit to keep them sound and progressively improving. To preserve the color, elderberry juice is mixed. The natural strength of the Figueira wines is 23.1 per cent. Experiments have proved the absolute necessity of fortifying the best growth of even Alto Douro. Some of the vintage of 1834, without a drop of brandy, was kept till 1861, and sent to London, where it was valued at only £8 to £9 per pipe, the cost to the maker having been from £25 to £30 per pipe. It is clear, then, that port wine drinkers are brandy drinkers without being conscious of the fact.

Of Sicilian wines, the strongest, the Faro, grown in the north-eastern district, has 22.7 per cent. of spirit, but it is exceeded by the Terre Forte of Mount Etna, which gives 29.9. The Neapolitan, known as Lachryma Christi, grown at the base of Vesuvius, yields only 18.9, but the Gallipoli rises to 26.5. Roman wine, known as Genzano, is 20.8. The Tuscan, called Montepulciano, contains 17.7 of spirit. The wines known as Bellit and Asti belong to Piedmont, but the strength is not given.

The total number of samples received from the various countries of Europe was 149, of which 24 did not represent pure or natural wine. The whole are thus classed: — 14 represent wine containing less than 18 per cent.; 89 contain 18 and less than 26; and 22 contain 26 and less than 40.

THE EFFECTS OF DIFFERENT MANURES ON THE MIXED HERBAGE OF GRASS LANDS.

At the last meeting of the British Association, in 1862, Messrs. Lawes & Gilbert stated that at a former meeting they had pointed out the great difference in both the chemical and botanical characters of the herbage induced by different kinds of manure, each applied for three consecutive years on the same lot in a portion of Mr. Lawes's park, which had been meadow for probably some centuries. Now, after the continuance of the experiment for four more years, they gave the results of a more complete botanical analysis of the produce. The full details were exhibited in tables, but the general results may be shortly stated as follows: — Unmanured, the land gave

38 species of plants, contributing in a more or less degree to the mown produce, of which about 75 per cent. was graminaceous, 6 per cent. leguminous, and 19 per cent. miscellaneous. Mineral manures, on the other hand, gave 37 species, and the produce contained only 68 per cent. of graminaceous and 9 per cent. of miscellaneous, but 23 per cent. of leguminous herbage. Ammonia salts gave 32 species; 89 per cent. of the produce being graminaceous, nearly 11 per cent. miscellaneous, and only 0.5 per cent. leguminous. When the mineral manures and ammonia salts were employed together, in quantities sufficient to yield large crops, only from 20 to 26 species could be detected, and from 90 to 95 per cent. of the total produce was graminaceous, there being scarcely a vestige of leguminous herbage then to be found. The influence of ordinary farm-yard manure, of nitrates, and other manuring substances, was also indicated. It happened that large crops could only be obtained when large amounts of nitrogenous as well as mineral constituents were employed; and, under these circumstances, the produce would be in very large proportion graminaceous, while leguminous herbage almost entirely disappeared, as also did numerous miscellaneous plants, though some few, as plantago, rumex, ranunculus, milfoil and carum, were one or more increased in quantity according to the description of the manure. In the experiments in question the largest crops were not only almost wholly graminaceous, but the great proportion consisted of but few genera, the principal being dactylis, poa, holcus, lolium, and agrostis. In fact, it seemed impossible to have at once large crops and great complexity of herbage. This was a point of considerable interest just now in connection with the question of the application of town sewage to grass land. In some experiments on the application of sewage at Rugby, it was found that the herbage became more simple, the bulk of the produce consisting of dactylis, lolium, and holcus, with scarcely any leguminous herbage, but a good deal of ranunculus, and more or less of some other weeds and other grasses than the three named. On a large proportion of the sewage meadows at Edinburgh, again, the produce was composed almost exclusively of three or four species, of which triticum repens and lolium perenne were the most predominant.

SEWAGE AND HEALTH.

In a paper recently read before the London Society of Arts, Mr. Rawlinson, a distinguished English engineer, stated that the death-rate of London and of the great manufacturing towns of England diminished just in proportion to the abolition of sinks and cesspools, and to the perfection and completeness of sewage drainage. The author maintained that if all the sewers were of sectional dimensions, forms, and gradients (as they might be), to transmit fresh sewage, and not retain it until putrefaction sets in, the public health would be further improved. The full and proper ventilation of sewers and drains was of the utmost importance; drains should be so laid and arranged as to render contamination of the air within houses by sewage gases impossible. Sewers should not pass beneath houses, and drains should commence at external walls, so that neither sewer nor drain should be beneath the basement of any house.

The Influence of Drainage on Public Health. — A remarkable instance of the influence of town drainage on the public health is shown in a report which has just been issued by the sanitary committee of the Halifax corporation in England. Great sewerage works have been constructed since 1851, and between that period and the present the death-rate has decreased from 25.39 per 1,000 to 21.48 per 1,000. This is in the town of Halifax itself; in the "Union" the mortality has only decreased $1\frac{1}{4}$ per cent., a fact which shows more clearly the beneficial operation of the sanitary improvements in Halifax.

SEWAGE OF CITIES.

In a paper recently presented by Prof. Voelcher to the Royal (Eng.) Agricultural Society, on the above subject, the author stated that the general conclusion he had arrived at was, that although sewage manure is very desirable for grass crops, it was next to useless for arable land or green crops, or even for market gardens. The value of sewage could only be ascertained experimentally on the field. Present experience only went to show that, according to the soil and other conditions, the town sewage of Edinburgh, which is rather more condensed than that of London, was worth only from one-half pence to one and a quarter pence per ton. In applying sewage, it was better to allow the deposit of suspended matters, and use only the clear liquid. As he had said, the only crops to which they could apply sewage to advantage were grass crops, and then it must be applied in great quantities and at the particular time when it was required. It should be applied, if possible, by gravitation and open irrigation, for no soil had the power of laying up in its body the greater part of the soluble fertilizing constituents. On poor sandy soils, the excrementitious matters of sewage were of great utility; but in reference to good clay soils, water was the most valuable portion of the sewage, the fertilizing matters being in that case of little or no importance, in fact hardly worth calculating; whereas, on light, poor, sandy soils, the value of sewage rose or sank with the amount of fertilizing matter applied to the land. So far from sewage being a great fertilizer of vegetable gardens, it certainly would not pay for the machinery and pipes necessary to bring it even from a short distance, and spread it on the ground. Anything that was grown very quickly was inferior in quality to the same kind of thing which was grown more slowly. Quickly-grown grass, for instance, was far more crude than that which was grown slowly — extreme rapidity of growth being always attended by inferiority of quality; but, of course, it was quite another thing whether it was not more profitable to producers to have the large increase in quantity, although it was attended by some degree of inferiority.

SEWER DEODORIZATION BY CHARCOAL FILTERS.

The investigations of Dr. Stenhouse, of London, in respect to the action of charcoal in deodorizing foul gases, etc., are generally well known. In a paper, however, recently communicated to the London Society of Arts, he gives a *resumé* of the opinions and results which he has arrived at, since the outset of his experiments, which is well worthy of attention. He says: — Towards the close of 1853, my attention was first directed to the deodorizing and disinfecting properties of charcoal; and I was not long in discovering that the views which had been previously entertained regarding the action of charcoal were exceedingly erroneous; for, instead of acting as an antiseptic, and thereby retarding the decay of putrefying substances with which it was in contact, as had been previously supposed, its action was the very reverse of this. Charcoal, therefore, from the considerable amount of condensed oxygen contained within its pores, amounting to between nine and ten volumes (and which, it might have been added, appears to be continually renewed of itself, unless the pores be allowed to be filled with water, or the charcoal, in other words, to become wet), not only absorbs, but rapidly oxidizes the effluvia and miasmata emitted by decaying substances, and resolves them into the simplest combinations they are capable of forming.

All porous substances, such as platinum black, pumice-stone, etc., possess the power of condensing gas within their pores.

The charcoal air-filter consists of a layer of charcoal in coarse powder, varying in size, according to circumstances, between a small bean and a filbert. The charcoal is placed between two sheets of wire gauze fixed in a frame, and can be readily applied to buildings, to ships, to the air-shafts of sewers, to water-closets, to respirators, and various other purposes. All the impurities in the air are absorbed by the charcoal, so that a current of pure air alone passes through the filter; and in this way pure air may be obtained from exceedingly impure sources. It is plain that perforated zinc, or a framework of coarse wire filled with larger pieces and a greater thickness of charcoal, may be also employed, whenever the amount of effluvia evolved is very considerable.

Before the close of the year 1854, air-filters or charcoal ventilators were fitted up both at the Mansion House and Guildhall. They are each of them several feet in diameter, the layer of charcoal being about one and a half inches in thickness. Although six years have elapsed, the charcoal has never required to be renewed, owing to its oxidating power being practically unlimited. Air-filters were soon afterwards largely employed in private houses, in connection with drains and water-closets particularly; and they were also very successfully applied to the construction of respirators, many thousands of which have ever since been annually manufactured.

Mr. Rawlinson, during the last four years, has applied charcoal air-filters to the ventilation of sewers on a large scale, near London, at Swansea, and other places. The efficiency of the charcoal appears never to diminish, if it is kept dry and its pores are not choked up by dust.

The expense of applying charcoal to the disinfection of the sewers is by no means considerable, as the first outlay is all that is required. The only precautions to be observed are, that while the filters shall be sheltered from rain and moisture, free access shall be given to the air. In conclusion I may state, that for the last six years I have strongly recommended that charcoal air-filters should be applied to all house-drains, sinks, and water-closets.

Every water-closet, in my opinion, ought to be furnished with a subsidiary pipe branching off from the main pipe, a little below the valve of the closet. This subsidiary pipe should be carried a few feet above the seat of the closet, and its extremity — which should be open, with the exception of a few wires stretched across it, merely to prevent the charcoal falling into it — should terminate in a charcoal filter six or eight inches thick, into which it should penetrate to the depth of two or three inches, so as, in fact, to be enclosed by a good body of charcoal. Under such an arrangement as this, no foul gases can penetrate into the closet.

From the preceding statements, it is plain that the oxygen contained in the air of the atmosphere is by far the cheapest and most effective deodorizing and disinfecting agent with which we are acquainted, and that the usefulness of the charcoal air-filter consists in its affording a safe and advantageous means of applying atmospheric air to disinfecting purposes.

UNWHOLESOME FOOD.

Animal poisons still constitute one of the most obscure problems with which chemistry and physiology have to deal. When the Tsetze fly, mentioned by Dr. Livingstone, kills his victim, the horse, by a wasting disease, how small in quantity must be the morbific matter, which, working we know not how, deranges the vital processes of nutrition and assimilation, and modifies the condition of all the fluids in the great body of the unhappy brute. When a German village suffers from the influence of the peculiar virus developed in badly-prepared sausages, or when a dish of mussels torments the admirers of that questionable variety of molluscous food, our analysts fail in their efforts to separate the peccant matter from the general mass, and our physicians are not more successful in the endeavor to explain the precise mode in which disease or death may supervene. We look to the general law that "a molecule in motion tends to communicate similar motions to other molecules within its influence," as expressing what probably takes place in the class of facts with which we have to deal; and although we may in some cases be able to discriminate between the varying amount of danger attending different stages of putrefaction, we cannot define the precise conditions in which a decaying substance exists when it is invested with the highest amount of deleterious power. Offensiveness to the sense of smell is no criterion, because sulphuretted hydrogen, and other gases, which make a violently unpleasant appeal to our olfactory nerves, are capable of existing quite independent of any organic poison, or miasma, which may or may not accompany them, according to the circumstances of the case.

When we have to deal with a preparation of arsenic, tobacco, opium, or any substance employed in medicine or the arts, we are able to extract a definite material which has little or no tendency to undergo further change, unless it is brought into contact with other bodies under certain conditions. Thus arsenious acid may be preserved unaltered for an indefinite period; the oil of tobacco or the alkaloids of opium will remain unchanged in our bottles; but when putrefaction assails an organized structure, the morbifi power that is evolved lies in the peculiar motions and changes which influence the ultimate arrangement of particles, and in the operation which they exert upon other substances susceptible of similar alterations in their condition. There is also another consideration that we must bear in mind, and which results from the complex arrangement of atoms in the organic world, or in products which may be derived therefrom. As an illustration of this complexity, let us look at the amylaceous and saccharine group of bodies, starting with cane-sugar, in which we find twelve equivalents of carbon, eleven of hydrogen, and eleven of oxygen. Professor Miller gives a list of eighteen substances of this group, exhibiting various elaborate combinations of a multiplicity of atoms of the three elements. In other groups belonging to the animal series, still greater complexity prevails, and as such substances are built up in a great variety of ways, so there is an equal variety in the modes in which they may be taken to pieces, and a change of properties — sometimes a very striking one — is found at every stage, whether of the ascending or descending scale. Thus we can understand how putrefactions — which are regulated modes of resolving complex bodies into simpler forms — may, under different circumstances, afford very different results.

These reflections will assist in explaining the great dangers which result from animal food in an unsound condition. If disease has changed the normal state of the particles, we may be sure that the food is made mischievous, although we may not, without experiment, be able to say to what extent any particular individual may suffer from eating it.

Professor Gamgee, in an important article on "Unwholesome Meat and Milk,"[1] classifies the evils of bad animal food under five heads, as produced by (1) Cadaveric venom and animal poisons of undetermined nature, developed spontaneously in health or disease. (2) Animal poisons well known from their effects in creating specific contagious diseases. (3) Organic poisons, the result of decomposition. (4) Mineral and vegetable poisons absorbed into the systems of animals, and which contaminate their flesh and milk. (5) Parasitic animals and vegetables, inducing disease in men. The learned professor is inclined to "regard as one and the same deleterious principle developed in an infuriated and over-driven ox, a passionate woman, the cadaveric venom of the human subject, or that of human beings or animals suffering many hours in labor, or from parturient fever." We may presume that the juices of an enraged philosopher would be quite as dangerous as those of a passionate woman; and in all these cases there is a connection between a certain mental or nervous condition, and the poisonous character which the solids or fluids assume. Mr. Gamgee says that he has frequently spoken to butchers on the subject, and received from them an account of how they have suffered from cuts received in dressing over-driven animals. In man, he tells us, the meat of such creatures produces violent dysentery, with febrile excitement.

Where specific malignant disease exists in animals, the danger of

[1] Edinburgh *Veterinary Review*, May, 1862.

using their flesh for food is exceedingly great, and very numerous cases of severe disorder and death are on record. With reference to pleuro-pneumonia, which brings so many beasts prematurely to the shambles, it is satisfactory to learn that, although the flesh is deteriorated, it "cannot be called poisonous;" and, strange as it may seem, the occurrence of this disorder has furnished the milkmen with a profitable mode of carrying on their trade. Professor Gamgee says, "In the city of Edinburgh there are dairymen who never knew what it was to make money until pleuro-pneumonia appeared. They originally paid ten or fifteen pounds for a rich-milking Ayrshire, which they kept a twelvemonth or more. They now pay twenty-five or thirty pounds for a fat cross-bred short-horn cow, which they calculate on selling diseased within three months from entering their dairy, and they find the latter system most profitable. . . . . . They have gone so far as to say, 'We do not want disease out of the country; it is keeping everything high.'"

PHOSPHORESCENCE.

The experiments of M. de Reichenbach tend to prove that phosphorescence is a usual consequence of all molecular phenomena, and not the result of combustion or oxidation. Mr. Phipson proved this last point some time ago, when he showed that dead fishes shine in the dark, even under water, and in the absence of oxygen.

According to M. de Reichenbach there is phosphorescence during fermentation or putrefaction, crystallization, evaporation, condensation of vapors, the production of sound (vibrations therefore), and the fusion of ice; a considerable glow is remarked when a galvanic pile in activity, a block of ice in fusion, or a solution of sulphate of potassa in the act of crystallizing, is observed in the dark. The human body itself is not devoid of phosphorescence. In a healthy state it emits a yellow glow. When in ill health the glow becomes red. The author considers that this observation may possibly be of use in diagnosis. To perceive these phenomena the eye ought to have been previously rendered sensitive by remaining some hours in perfect darkness, and even then all eyes are not equally impressionable. But, if several persons unite in performing the experiment together, there will always be a certain number who are able to see the phenomena.

These facts of the production of light remind the author of observations published some time ago by M. Wullner, according to which every molecular movement is accompanied by a disengagement of electricity. — *Poggendorff's Annalen.*

PHOSPHORUS IN THE BRAIN OF MAN AND ANIMALS.

As the results of various chemical examinations, Prof. Borsarelli arrives at the following conclusions: 1. The medium quantity of phosphorus found in the brain of man and some other animals is more than triple that assigned to this organ by Persoz and Opermann. It varies from 1.352 to 1.790 per cent. 2. The phosphorus of the animal economy is found in largest quantity in the brain, in a less proportion in muscle, and in a still less proportion in the stomach. 3. In man, the quantity of phosphorus increases in a decided manner, in proportion to his years, in the brain and in the muscular flesh, and in a less marked manner in the stomach. 4. The less quantity of phosphorus found in individuals under puberty, whose development is not completed, arises from the greater quantity of this metalloid required for the solid parts of the frame. 5. The difference in the quantity found in an adult or a person of advanced age and an individual under puberty, amounts, for the brain, to 1.14 compared to 1, and for the muscular substance to 2.19 as compared to 1. 6. The amount of phosphorus found in the adult or aged person, and in the ox, the calf, the sheep, and the hog (with the exception of the flesh of this last), is very much the same, — the average being, as regards the brain, 1.560 in man, and 1.553 in the animals; and as regards the muscular substance, 0.872 in the former, and 0.876 in the latter. In the hog, however, the flesh contains 1.012, being rich in phosphorus, as compared with that of the other animals examined as 1.15 to 1. This may be one of the reasons why the flesh of this animal is more stimulating than that of others. 7. Flesh by boiling in water loses one-half of its phosphorus; so that the flesh of the hog, which uncooked contains 1.012 per cent., after boiling only contains 0.567. Hence we see why in practice boiled meats are found to be most suitable for the convalescence of those who have suffered from hyperæsthenic diseases, and why roasted meats impart vigor to those whose strength has become exhausted by those of a debilitating character. The good effects of meats so cooked do not, however, solely arise from the presence of a greater proportion of phosphoric compounds. They also contain a larger quantity of the proper nutritive principles of the flesh, which, being soluble in water, become lost in boiling. — *Omodei's Annali Aniversali.*

CLEANING AND PRESERVATION OF ENGRAVINGS.

In a communication addressed to the *Scientific American*, Dr. A. A. Hayes, of Boston, describes the following process for restoring valuable engravings which have become damaged through accident or exposure. He says: —

In commencing to restore an engraving, some attention must be given to the kind of injury it has suffered. A general brown color, more or less deep, resulting from atmospheric action only, is the least possible change. Spots and stains, caused by ink, colored fluids, oil, or insects, must be first treated, and all pencil marks removed by India-rubber or bread crumbs. A fluid acid, obtained by dissolving one ounce of crystals of oxalic acid in one-fourth of a pint of warm water, may be used for application to all stains, and the paper should be wet with it thoroughly where spots of any kind exist. Excepting in a few cases, this acid will not cause the removal of stains immediately, but generally it combines with the bases of them, and they are removed by subsequent steps; the thorough wetting should be done a few hours before proceeding to clean the engraving. The engraving should then be placed in a shallow tub or other vessel, and allowed to rest upon a piece of open cotton stuff, or millinet. This material, of suitable dimensions, should have two rods or sticks sewn to opposite edges. These sticks will hang over the sides of the vessel, and permit the prints to be withdrawn or moved without any risk of injury, and they should remain in soak with warm or cold water for twelve or twenty-four hours. When the prints no longer discolor the water on being agitated, the fluid should be withdrawn, and enough clean water added to cover them. Half a pound of chloride of lime should be made into a paste with cold water, and stirred up with two quarts of water, and allowed to settle for six hours. Part of the clear solution should be added to the bath till the smell of cholorine is perceived, and the prints should be moved to facilitate the action. In very bad cases, one ounce of muriatic acid mixed with a pint of water may be added, and when the bleaching is effected the prints should be well washed with fresh water and slowly dried.

On the first trial of this process, remarks Dr. Hayes, a degree of alarm will be felt in the case of a highly-prized favorite at this seeming careless treatment; but it must be borne in mind that paper is a firmly felted mass of short fibres which may be soaked in various fluids for weeks, and resist all diluted acids and most chemical agents for a long time wet, if not exposed to mechanical abrasion by touch or rapid motion.

NEW THEORY OF ODORS.

A physical theory of odors and savors has been put forth by M. Nicklès, who has sought to establish some general laws which preside over the generation and perception of these two properties of bodies. He attributes the formation of odors to three categories. 1. The combination of two inodorous bodies. 2. The action of an odorous on an inodorous body, and reciprocally; and, 3. The combination of two odorous bodies, which produce either an odor like one of the elements, or an odor entirely new. As examples of the last he cites butyric and ether with the odor of ananas, the essence of apples, and the essence of Gaulteria. M. Nicklès finds that there are bodies endowed with a peculiar odor which persists and rules in a great number of combinations, in the same manner as the color or taste of certain bodies is maintained in certain combinations. Two bodies perform an important part in the theory of odors. Hydrogen develops the odor of the bodies with which it combines, and, at the same time, renders them more volatile. Oxygen, on the contrary, diminishes the volatility and odorability of the compounds. Yet oxygen is indispensable to the perception of odors. It seems always to intervene in that act, and perfumes make an impression on the olfactory nerves only in proportion as they are burnt by the air of the atmosphere. Hydrogen and oxygen are inodorous in the pure state. Their compound, water, has an odor, which may be perceived when drawing it into the nostrils. In general, the odor and taste of other compounds take from the electro-positive element, which may be a compound radical. There are very few exceptions to this remarkable law. As to savors in particular, M. Nicklès attributes them to catalytic action, or the effects of contact.

PRODUCTION OF NITRATE OF AMMONIA BY AIR AND WATER.

M. Schönbein has shown that nitrate of ammonia is formed at the expense of air and water during the slow combination of phosphorus. He has likewise proved that this salt is present in meteoric waters, and has thence concluded that its formation must be due to a very general cause. He now announces that this cause is found in the simple fact of the volatilization of water in free air, and he cites many experiments which confirm this belief. The process which succeeds the best is to cause water to fall drop by drop in a metallic vessel heated above 100° C., without, however, reaching the point at which the liquid passes into the spheroidal state. By holding a cold flask above the vapors which are produced, he condenses enough water to recognize the presence of nitric acid and ammonia. M. Schönbein has remarked that the quantity of nitrate of ammonia condensed with the vapor of the water is very variable, sometimes almost *nil*, and he is disposed, in the absence of any positive determination, to attribute these variations to changes of temperature. It is not, however, necessary that the water should boil, as the salt is produced during all evaporation, and its presence may be shown in the water that remains after a portion has been evaporated. A sheet of filtering paper dipped in pure water, and dried in the air, becomes impregnated with sufficient nitrate of ammonia to be distinguished in the water with which the paper is washed, and it can be discovered in linen that has been washed and hung up to dry. In all these cases the production of nitric acid may be rendered more evident by adding to the water which is evaporated a little potash, to fix the acid. Wet sand dried in the air becomes impregnated with nitrate of ammonia.

ACTION OF NITROGEN AND NITRIFICATION.

This interesting subject has been brought before the Academy of Sciences, Paris, by Mr. Sterry Hunt, in a note read at a recent meeting. He attributes the simultaneous production of an acid of nitrogen and ozone, whether by the electric spark, or by the slow oxidation of phosphorus, to the power which oxygen possesses of burning ammonia, thus setting at liberty the acid of a small quantity of nitrate of regenerated ammonia, and even, according to the observations of M. Houzeau, carrying its oxidizing action so far as to acidify the nitrogen of the atom of ammonia. Thus, as some chemists have maintained, certain reactions attributed to ozone are due to a small quantity of nitrous acid, which is formed when the active oxygen is formed, while the active oxygen is in contact with the moist atmospheric nitrogen. On the other hand, the hydrogen set at liberty by certain reagents would have the effect of destroying the nitrous acid of the nitrate of regenerated ammonia, thus setting at liberty the ammonia of the salt, and forming a second atom of ammonia, in consequence of the reduction of the acid. Mr. Hunt asserts that the experiments of Professor Schönbein confirm his theory in a remarkable manner. He adds that Professor Schæffer, of Washington, twelve years ago, in a memoir on the means of recognizing the presence of small quantities of the acids of nitrogen, affirmed that rain water, free from all traces of a nitrate, acquired a strong reaction of it after having been exposed to the air for some hours during the heats of summer.

A NEW STIMULANT.

Reports have, from time to time, of late years, come from South America, respecting the peculiar properties of the leaves of the *Erythroxylon Coca*, which are said, when chewed like tobacco, or infused as tea, to have the power of sustaining the bodily strength under prolonged fatigue and privation of food and sleep; and that, too, without producing, if used in moderation, any subsequent reaction. Within the last year, Dr. Gosse, of Geneva, has given to the world, in the *Proceedings of the Belgian Academy*, a monograph of this interesting plant, in which, so far as testimony can be trusted, the effects in question may be considered as fully established, if not to the almost miraculous extent which some of the accounts describe, at least quite sufficiently to prove it a most valuable auxiliary under very extreme circumstances of hard labor and privation of nutriment.

The *Erythroxylon Coca*, *Ypadu*, or *Hdyo*, is a shrub of from two to eight feet in height, very abundant in branches and leaves, which is cultivated extensively in many parts of Peru, and in Bolivia, chiefly on the inferior slopes of the Andes.

Prof. Mantegazza, who was in the habit of using it daily for two years, describes its effects, when taken *after* a meal (the dose, from twenty to thirty grains of the leaves, infused in a cup of boiling water or chewed), as producing in a very short time that state of ease and comfort which accompanies a perfect digestion, so marked that it is impossible for one ever so habitually inattentive to his own sensations not to be struck with its advantageous effect in accelerating and facilitating this important function. Taken fasting, it seems to destroy the desire of food, not, however, by creating any degree of nausea or depression, but, on the contrary, exciting and sustaining the bodily power so as to render food unnecessary. Instances of its agency in this direction on the Indian laborers, porters, couriers in the Andes, etc., are given in the memoir of Dr. Gosse in great numbers. Thus, to give a single instance, on the authority of Mr. Stevenson, who resided twenty years in South America, where he had abundant occasion to witness its effects, he relates that "the natives of many parts of Peru, especially in the mining districts, chew this leaf while working or on journeys, and such is the nutrition they derive from it, that they often pass four or five days without taking any other nourishment, even while working without interruption. "They have often assured me," says Mr. Stevenson, "that, provided with a good supply of coca, they experience neither hunger, nor thirst, nor fatigue, and that without injury to their health they can remain eight or ten days, and as many nights, without sleep."

Used in moderation, as before observed, for however long a period, it does not appear to exercise any deleterious influence on health. Taken as a stimulant, however, and in over-doses, its use is, no doubt, to be deprecated, as leading to consequences as serious and deplorable as the habitual use of opium, or any other stimulant or narcotic.

The coca leaf has been subjected to chemical analysis by M. Niemann, a pupil of Professor Wöhler, of Göttingen, who succeeded in insulating from it a peculiar alkaloid, to which he has given the name of "cocaine."

POISONOUS EFFECTS OF CARBONIC OXIDE.

Dr. Letherby, of the London Hospital, who has recently devoted much attention to physiological action of carbonic oxide, states that he has ascertained that this gas is so deadly in its action that air containing only 0.5 per cent. of it will kill small birds in about three minutes; and that a mixture containing one per cent. of the gas will kill in about half this time. An atmosphere having two per cent of the gas will render a guinea-pig insensible in two minutes; and in all these cases the effects are the same. The animals show no sign of pain; they fall insensible, and either die at once with a slight flutter, hardly amounting to convulsion, or they gradually sleep away as if in profound coma. The post-mortem appearances are not very striking; the blood is a little redder than usual, the auricles are somewhat gorged with blood, and the brain is a little congested. In birds there is nearly always effusion of blood in the brain, and it may be seen through the transparent calvaria by merely stripping off the scalp after death.

Accident has also demonstrated how injurious the gas is even to the human subject. For many years past attempts have been made to promote the use of water-gas as an agent of illumination. The gas sometimes contains as much as thirty-four per cent. of carbonic oxide. It is obtained by passing steam over red-hot charcoal; and as the steam is decomposed by the ignited carbon, the hydrogen is set free, and carbonic oxide, with carbonic acid, is produced. Patents for this process of manufacturing gas date as far back as the year 1810, and they have at various times been put into operation into this country and on the Continent. Sellique, in 1840, obtained permission to use the gas in the towns of Dijon, Strasburg, Antwerp, and two of the faubourgs of Paris and Lyons. At Strasburg an accident occurred which put a stop to its use. The gas escaped from the pipes into a baker's shop, and was fatal to several persons; and not long after an aëronaut, named Delcourt, incautiously used the gas for inflating his balloon. He was made insensible in the car, and those who approached the balloon to give him assistance fainted and fell likewise. The use of the gas has, therefore, been interdicted on the Continent.

CARBONIC ACID AS AN ANÆSTHETIC.

Dr. Ozonam has recently detailed to the French Academy his experiments on the above subject. After forty trials with delicate animals, whose sleep he had prolonged for one or two hours at a time without accident, he operated upon a human subject suffering from a deep abscess in the thigh. He begun by administering a mixture of three parts of carbonic acid and one of common air contained in a caoutchouc bag, and furnished with a long tube, terminating in an enlarged opening, capable of receiving the mouth and nose. This was applied so loosely that the patient could respire air as well as the gas mixture. In two minutes he was asleep, with accelerated respiration and abundant perspiration from the face. This last phenomenon, Dr. Ozonam observes, appears to be the result of a specific action of carbonic acid, which produces it if directed upon the skin as a douche, or in a bath. The patient evinced no consciousness when the incision was made, but the inhalation of the gas was suspended just before the last cut, which was felt, and the young man awoke. When the gas is properly administered, consciousness is recovered as soon as the process is suspended, and Dr. Ozonam claims for his method greater safety than belongs to chloroform.

NEW USE FOR CARBOLIC ACID.

Dr. J. G. Ashby, in a communication to the London *Mechanics' Magazine*, thus notices a remarkable property possessed by carbolic acid in relation to practical mechanics. He says: "Carbolic acid is one of the products of the destructive distillation of coal, and till within a few years vast quantities of it were utterly wasted. When perfectly pure it is a white crystalline solid, which by absorbing water soon changes into a colorless refractive liquid, having a faint odor of roses and tar. It is not an acid in the popular sense, not being either sour or corrosive, and should therefore, perhaps, be generally designated by its other title of phenole. Crude carbolic acid may be obtained in bulk for about a shilling a gallon, and is a dark tarry liquid, containing, perhaps, from ten to twenty different substances, in a state of mechanical admixture. Fortunately, this crude acid is available for the purposes to which I invite the attention of your readers. Just as oil is an anti-frictional liquid, so is phenole pro-frictional; or, to state it more correctly, as oil appears to keep surfaces in motion asunder by interposing a thin film between them, so phenole appears to make them bite and bind, by bringing them into absolute contact (after a manner of speaking), and removing even the finest film from between them. Any one may convince himself of this by placing a little upon a perfectly clean and dry oil-stone, and then rubbing up the face of a broad chisel upon it. The sensation of the bite — I know of no other word to express it — is very curious, and renders any further explanation unnecessary; it seems as if the stone and the steel had absolutely nothing between them, or even as if they were positively brought together by some attractive force. I have applied this property of carbolic acid to the following operations, viz., grinding, filing, boring, and sawing in metal, with great apparent advantage. When dissolved in fifteen parts by measure of methylated alcohol, it forms a milk-white emulsion if poured into water, and it may be worth while to ascertain whether such carbolated water would facilitate the ordinary work of the grindstone, a point on which I am not able to speak with certainty."

THE MANUFACTURE OF COLOR PRODUCTS FROM COAL-TAR.

From a lecture recently delivered to a popular audience at the Royal Institution, London, by Prof. Playfair, we make the following extracts, in which this celebrated lecturer on science thus clearly traces the various steps by which the well-known colors, mauve, magenta, etc., are manufacted from coal-tar:—

Coal-tar is a very complex body. It contains a large number of substances, some of which are volatile, others more difficultly volatile, and others not at all volatile in the ordinary sense of the word.

I have here a retort filled with tar, and I am now going to pass through that a current of steam; and you will see that after a little while, when it passes through freely, it will distil over along with the water, and that this water will contain, swimming on its top, a certain quantity of naphtha. The steam which passes through the tar will take away the more volatile portions of the tar and condense it upon the top under the name of naphtha. What remains behind is a mixture of what is called dead oil and pitch. This dead oil is afterwards distilled off, and what remains behind in the retort is finally pitch.

In distilling it in this way we obtain from one hundred parts of coal-tar, of naphtha nine parts, of dead oil sixty parts, and of pitch thirty-one parts, so that there are various substances obtained. I have only time, however, to deal with the naphtha. Now, naphtha itself, or the substance which we get over by distilling the tar with steam, is a general word also. The crude naphtha contains, first, basic oils, or oils acting as bases; secondly, acid oils, or oils acting as acids; and, thirdly, neutral hydrocarbons.

This naphtha is purified and clarified. There is added to it sulphuric acid. The sulphuric acid takes up the basic oils, unites with them and forms salts — sulphates of these bases. The sulphuric acid unites with the basic oils and produces this "sludge," as it is termed by the manufacturers — the bases united with the acid.

Now, these are extremely valuable, and it is from them that coal-tar colors are obtained; but they are entirely lost by the manufacturer. They will probably be saved afterwards, but at present they are thrown away as a sort of tar. The first things that we obtain of any advantage are the acid oil and the naphtha. The naphtha itself, the crude naphtha, is employed at once, without any purification, for the purpose of making India-rubber water-proof coats and similar articles. But it is purified for various very important purposes. When the most volatile portions are collected, what comes over are the acid oils. Now, these acid oils consist of two acids, carbolic acid and cressylic acid. Carbolic acid has the formula $C_{12}H_6O_2$; and the cressylic acid is what is called a homologue of the other, or contains C_2H_2 more. It consists of $C_{14}H_8O_2$. Common creosete is a mixture of these two acids. This carbolic acid which forms common creosote is, after purification, and when perfectly dry, a solid, and forms one of the most powerful disinfecting agents. When this acid is treated with nitric acid it loses part of its hydrogen, and that hydrogen becomes replaced by peroxide of nitrogen, a lower oxide of nitrogen than nitric acid. When it is treated with nitrogen three of these go away, and the hydrogen is replaced by what is termed a compound radical — a body which plays the part of hydrogen, and which forms a yellow substance called carbazotic acid. Carbazotic acid is carbolic acid, three of whose equivalents of hydrogen have been substituted by three equivalents of an oxide of nitrogen.

Now, this carbazotic acid can be prepared in large quantity from creosote by the action of nitric acid, and it can be employed at once for dyeing. If I take a skein of silk and agitate it for a little in carbazotic acid, it will take on the dye without any previous preparation, and assumes a beautiful yellow color. This material has also been lately employed, as almost everything is employed, for various other useful purposes. It is an excellent antiperiodic, like quinine, only when employed it dyes the skin of the patients yellow, and they, therefore, have a sort of artificial jaundice. But it has also been suggested for another purpose. It may be mixed with arsenic and other poisons for the purpose of rendering them more ready of detection. It imparts to the arsenic a bitter taste, and it also turns the person to whom it is administered yellow, and in a case of slow poisoning this yellow appearance would be an indication that there was something wrong.

Cressylic acid, another of the compounds of crude tar-oil, is not much employed in the separate state.

I now pass to the neutral hydrocarbons. The neutral hydrocarbons are also various. They are called benzol, toluol, xylol, cumol, cymol, and a great many other names with which I will not trouble you. They are compounds of hydrogen and carbon, and possess many degrees of volatility. For instance, benzol boils at 177°. This is one of the most useful of the substances. It is made from crude naphtha by a simple operation, taking advantage of its low temperature of ebullition. Here is a benzol still. The crude naphtha is placed in this still. It is a double still, into which steam is sent from this steam-boiler in order to heat the crude naphtha. The top of the still, you will observe, passes through a cistern of water. That cistern of water is kept at the boiling point of benzol, 177°, and the vapor of the naphtha passes through the heated vessel, which is heated to 177°. Benzol distils over at 177°; but toluol, cumol, cymol, and the others, boil at a much higher temperature. Therefore they are condensed at that temperature, and fall back into the still. The separation is, therefore, effected simply by means of keeping the benzol at its own boiling temperature, and cooling the others below theirs. It is a very volatile substance. It, no doubt, adds much to the illumination of our coal gas.

Now, this body, when acted upon by nitric acid, produces nitro-benzol. I must call your attention to nitro-benzol a little scientifically. Benzol has the formula $C_{12}H_6$ — that is, it contains twelve equivalents of carbon, and six of hydrogen. In nitro-benzol one of these equivalents of hydrogen goes out, and one equivalent of oxide of nitrogen, NO_4, goes in and substitutes it, and then forms nitro-benzol, a substance which by itself possesses some peculiar characters. It smells strongly of bitter almonds, and it is employed now instead of bitter almonds, which is poisonous, for making common almond soap. The common almond soap which we buy is now perfumed with nitro-benzol. It is also employed in confectionery as a substitute for bitter almonds. It is much better for that purpose, because the bitter almonds contain prussic acid, and by the use of too large a quantity by our cooks we may poison our friends. There is no chance of that taking place when nitro-benzol is used. It is the basis from which we derive our tar colors, and the mode in which it is used for this pur-

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pose will require a little close attention to a chemical formula; but it is very interesting.

If nitro-benzol is acted upon by water and by iron, of which I have put down the symbols here, — nitro-benzol + water + iron = $C_{12}H_5(NO_4) + 2HO + 4Fe$, — the iron takes away all the oxygen from the water, and the oxygen from the oxide of nitrogen. There are six equivalents of oxygen, which the iron takes to itself and forms iron-rust with it. The rust remains, and the two of hydrogen of the water now joins itself to the $C_{12}H_5N$, and produces this body here, $C_{12}H_7N$, aniline. That is to say, the iron takes away the oxygen, and leaves oxide of iron and aniline as the result.

Now, this aniline is a most important body. It was first investigated by Dr. Hoffmann, who has made with regard to it a series of the most brilliant researches, out of which have arisen these coal-tar colors with which we are now acquainted. Aniline is an ammonia. It is a body exactly resembling the base ammonia, but it is what is termed a compound ammonia. Here is the constitution of ammonia: —

$$N\left\{\begin{matrix} H \\ H \\ H \end{matrix}\right.$$

I put down the three atoms of hydrogen separately. Now, if I take away one of these atoms of hydrogen, and substitute it by one of something else which plays the part of hydrogen, I form a compound ammonia. I will do so in this case.

$$N\left\{\begin{matrix} C_{12}H_5 \\ H \\ H \end{matrix}\right.$$

I have replaced one atom of hydrogen with a compound radical which chemists call phenyle, and I obtain what is termed aniline. This aniline is, therefore, a compound ammonia in which the radical phenyle replaces one of hydrogen.

Now, it is out of this aniline that we produce mauve, magenta, roseine, azuline, bleu de Paris, and the various colors which have received arbitrary names. It was known for a long time that the products of distillation of coal had a strong tinctorial power. Here, for instance, I have two of them, a body called pyrrole. I have here a piece of pine wood, made for a theatrical purpose, in the shape of a dagger. I will now moisten this with muriatic acid, and then place it in a deep vessel which contains a few drops of pyrrole. You see that it suddenly gets as it were covered with blood. Now, this tinctorial power has been known, in fact, for a long time, but the mode of manufacturing the substance readily and economically was not known. Here I have a small quantity of aniline, and I agitate it with water; and now, if I add to that a solution of bleaching powder, you will see the effect it produces. It was long known that this aniline gave a purple color with bleaching powder. The color comes after a little while; it does not come immediately, but you see, as I add it, that the aniline produces a mauve or a purple color; and this was known for many years, before persons knew how to make it for commercial purposes. This is now a color used in the arts. The first person who introduced this, and to whom the greatest credit is due for its production, was Mr. Perkin. Mr. Perkin had seen and admired the tinctorial power of aniline, and he had an ambition to render this fugitive color permanent, and to introduce it into the arts as a dye, and he succeeded admirably. The mode is this: this aniline is a base, and unites with sulphuric acid as ammonia does, and it forms sulphate of aniline. He takes equivalent quantities of aniline and bichromate of potash, and mixes them together, and in a little while, after standing together, they form this very unpromising-looking black powder. You see this black powder here; it looks extremely unlike a dye. Now, when this color is washed with coal-naphtha, this nasty-looking brown resinous substance is dissolved out of it by the coal-naphtha, and then there remains a still unpromising substance, but which is rather purple in color. When you treat with alcohol this brown powder, which has been washed with naphtha and had the resin taken out of it, it forms with the spirit a strong solution of mauve. This beautiful purple color is obtained in this way, by dissolving out of the brown powder the purple color by means of alcohol; and it is this purple color which is used largely in dyeing. It is readily soluble in alcohol.

It is easy to dye with this aniline purple; in fact, ladies can dye with it perfectly themselves. It is only necessary to use for this purpose hot water — water so hot that you cannot bear it with your hand, but not boiling. The best temperature is about one hundred and fifty degrees. If you take hot water and add to it a little tartaric acid and a little of aniline purple, and then place the silk or woollen in it, it becomes dyed. It is easy to attach the color to animal fibre, but not to cotton. I have here the coloring matter, and now I will add to it a solution of tartaric acid, which is necessary to produce the color. After that all I require is to place my silk in this solution, and to rinse it for a little time in it, and you see that it quickly takes up the color and produces that beautiful mauve which is now so familiarly known. It is, therefore, a substance which is extremely easily applied — almost as easily as the carbazotic acid.

Through the kindness of Mr. Perkin, I am enabled to exhibit to you magnificent specimens of his aniline purple, or mauve, in the dry state and in solution. This brown lump, with the remarkable coppery lustre, is mauve in the solid state. Its extraordinary tinctorial powers will be appreciated, if I tell you that this beautiful violet-colored solution contains not more than one-tenth of a grain of mauve in a gallon of alcohol. You will also understand the considerable commercial value of this substance. Weight for weight, this coloring matter, when pure, is sold at the price of metallic platinum.

Very little is known regarding the chemical nature of mauve; its composition is not yet made out, and as a matter of course the process by which it is formed from aniline remains as yet perfectly unexplained.

Magenta is one of the fancy names given to the splendid crimson which is likewise generated from aniline by the action of oxidizing agents. This substance was first observed in purely scientific researches, and more especially in the action of tetrachloride of carbon upon aniline. To a French chemist, M. Verguin, the merit is due of having for the first time obtained this substance on a larger scale. He produced it by the action of tetrachloride of tin on aniline. Numerous other processes were subsequently suggested, among which treatment of aniline with chlorine, or nitrate of mercury with arsenic acid, and many other substances, may be mentioned. Magenta, often called fuchsine, roseine, etc., soon became an article of large consumption. A great impetus to this new branch of industry was given in France by Messrs. Renard and Franc, who were the first to manufacture the new article on a commercial scale, and the production has now attained colossal proportions. Before proceeding, however, let me show you the formation of magenta by experiment. Among the many processes which I might adopt for this purpose I select the action of corrosive sublimate upon aniline, not because I consider this process superior to the others,—it is, in fact, inferior to many,—but because it is, perhaps, the best adapted for a lecture experiment. This white powder is chloride of mercury (corrosive sublimate); a small portion of this salt I mix in a test tube with perfectly colorless aniline. Let us stir the mixture with a glass rod until it is converted into a perfectly homogeneous liquid paste. This paste is still colorless, but on gently heating it by a gas burner it instantaneously assumes a splendid crimson of the greatest intensity, a single drop of the liquid being capable of deeply coloring a large beaker filled with alcohol.

In all the processes which convert aniline into coloring matters, a considerable number of secondary products are generated, which it is rather difficult to separate from the principal product of the reaction. These difficulties have been most perfectly overcome by Mr. Nicholson, who has succeeded in obtaining magenta in a state of absolute purity. Chemists have thus been enabled to analyze this substance, and to lift, at all events, the corner of the veil which still covers the mysterious formation of the colored derivatives of aniline.

In the pure state, magenta is a fine crystalline, and, remarkably enough, perfectly colorless, or only slightly tinted body, which is represented by the formula, —

$$C_{20}H_{21}N_3O = C_{20}H_{19}N_3, H_2O.$$

Rosaniline (this is the name by which chemists designate the colorless body) is a base, or ammonia derivative, which forms a series of splendid salts. It is in the state of saline combination that rosaniline acts as a crimson dye. Into this shallow porcelain dish I have thrown a few crystals of rosaniline, which at a distance you scarcely perceive. I now pour upon these crystals a small quantity of acetic acid, when on gently heating the dish the crimson color instantaneously appears. But it is only in solution that even the salts of rosaniline are crimson colored. On slowly evaporating their solution, the red color entirely vanishes, and a splendid green crystalline substance remains, presenting in an extraordinary manner the beautiful metal lustre which distinguishes the wings of the rose beetle.

Having now explained the several stages of transition through which coal has to pass before it either becomes mauve or magenta, it may be of some interest to you to know the proportion which the finished dye bears to the coal from which it is derived. A set of specimens, for which I am likewise indebted to Mr. Nicholson, is most instructive in this respect. Observe, it commences with a large mass of coal, weighing not less than one hundred pounds,; the bottles which follow contain the coal-tar oil, naphtha, benzole, nitro-benzol, and aniline, obtainable in succession from one hundred pounds of coal. Remark how they gradually diminish in size, and how small, I might almost say insignificant, appears the bulk of magenta finally obtained. But compare the bulk of wool which this minute quantity will dye. It approximates to the bulk of coal with which we started. This comparison evinces perhaps sufficiently the extraordinary tinctorial power which this class of dye possesses; but a very simple experiment may possibly convey to you this idea even in a more impressive manner. The white paper which covers this large frame has been dusted over with a minute quantity of mauve; a second one is treated in a similar manner with magenta. The quantity of coloring matter is so small that the paper has retained its original white color; but observe how it changes when I dash a beaker full of spirit against these squares. Immediately the lovely purple of mauve is developed upon one of them, while the other one exhibits the dazzling crimson of magenta.

As a new art, the manufacture of these colors is of great importance. Hitherto England has been dependent upon foreign countries for its dyes. We have imported madder from Holland, from Turkey, and from France, and blue colors from India, in order to produce our calico prints; but you see now we are likely to reverse this. We find in this waste product, coal tar, the three primitive colors, out of the mixture of which we can produce almost any shade we desire.

THE USE OF MORDANTS.

In order to remove the mordants used in fixing the colors upon printed cottons, the calico-printer formerly made use of a curious process, which was, to pass the cloths through baths in which the dung of cow-houses was placed. In this way all the soluble mordants were converted by the cow-refuse into insoluble substances, which could no longer attach themselves to the cloth and cause a confusion of the colors. In consequence of this operation large dairy establishments were connected with print-works, so that the printer might have a sufficient quantity of cow-refuse for his purpose. After a time, when the action of this substance began to be properly understood, chemists asked themselves whether some substitute could not be used, so that this objectionable process might be dispensed with. They soon discovered that the peculiar action of this refuse upon the mordants was due to the phosphates which it contained to a considerable extent; and it was then easy to make artificial phosphates,— phospate of soda and phosphate of lime,—and these were mixed together with glue, and sold for a long time under the name of "dung substitute." Within the last few years chemists have found that even these phosphates are not required, and that it is better to use arseniate of soda—arsenic acid united with soda. You may have some idea of the enormous quantity of this highly poisonous salt that is used, when in Lancashire alone five hundred tons of this arseniate are annually made for the purposes of the calico-printer.

The use of this substitute has a great advantage. The material is added to the bath, and you may pass several thousand pieces through the same bath, by adding a little additional arseniate of soda. The same bath may thus be used for several thousand pieces without being changed; but in the old plan, where cow-dung was used, it was necessary to change the bath after a few pieces had been passed through it; so that the application of these phosphates and arseniates to the purposes of the calico-printer has enormously aided him in diminishing the necessity for labor. — *Sir Lyon Playfair's Lecture.*

The Action of Mordants in Dyeing. — In a paper on the above subject, recently read before the London Chemical Society, by Mr. W. Crum, the author opposed the idea that in dyeing, any chemical union took place between the fabric and the dyeing material. He regarded the action in some cases as one of adhesion to an extended surface; in others, where the coloring matter (or mordant and coloring matter) is in solution, absorption took place. The structure of the fibre bears out this view, for on examining cotton under the microscope it is seen to be composed of flattened tubes with translucent walls, permeable, no doubt, to fluids. When mordants are used they are often deposited within the fibre, and retained there mechanically, and afterwards, combining with the dye, serve to fix it in the material. What is technically termed *dead cotton* does not take the dye, for, being immature or imperfectly formed fibre, it possesses no central tube; it occurs in small quantities along with ordinary cotton, and remains white and unaffected after mordanting and dyeing. Mr. Crum exhibited numerous specimens of dyed and printed cotton fabrics in which threads and bundles of undyed dead fibres were very well seen.

MINERAL OILS.

The *Journal of the Franklin Institute* publishes the following table of the economy of using petroleum oils as compared with Philadelphia gas, spermaceti, paraffine, and adamantine candles: —

Name of material burned.	Material. How burned.	Quantity burned in same time as 1000 cub. ft. of gas.	Relative cost of material burning in equal time.	Cost for an average winter evening of five hours.
Philadel. Gas,	5.1 cu. ft. pr. hr.	1000 cub. ft.	$2.10	5⅓ cents.
Petroleum,	Large lamp.	1⅝ galls.	0.73	1⅞ "
do.	Smaller do.	1 "	0.45	1.14 "
Spermaceti,	Two candles.	7¾ lbs.	3.87	9⅞ "
Paraffine,	do.	7 "	2.24	5.7 "
Adamantine,	do.	10 "	2.25	5¾ "

Naphthometer, or Benzine Detector. — This new instrument, the invention of Messrs. H. J. Smith and W. Jones, of Philadelphia, consists of a reservoir with a tightly-fitting cover, from the top of which projects a tube, surrounding a wick tube. A thermometer also passes through the cover, and occupies such a position that its bulb comes within a short distance from the bottom of the reservoir. In order to determine the temperature at which the oil gives off sufficient vapor to cause an explosion, the oil to be tested is poured into the reservoir, the wick is lighted, and the instrument placed on a stove or over the flame of a lamp. At a temperature which varies in proportion to the quantity of explosive ingredients contained in the oil, the vapor is given off, and, mixing with the air in the reservoir, passes up through the space between the wick tube and the larger tube, and explodes when ignited by the flame, thereby extinguishing the light. The height of the mercury in the thermometer will determine the quality of the oil.

The contrivance is very simple and cheap, and enables any one to ascertain in a few minutes whether an oil is of a quality to be burned with safety.

Explosiveness of Mineral Oils. — From investigations into this subject recently made in England, it appears that no danger can arise from the use of petroleum or coal-oil if it be properly refined. To ascertain whether this necessary process has been effectively performed, it is only necessary to place the oil in an open dish in a water-bath, and heat it to a temperature of one hundred and thirty degrees. If when elevated to this heat it does not ignite by the application of a match, it is safe; but any oil igniting at a temperature below one hundred and thirty degrees is dangerous, and should not be used for domestic purposes.

English Legislation respecting Mineral Oils. — By an act passed by the British Parliament, in 1862, it is provided that "not more than forty gallons of petroleum, which, by the first section of the said act, it is declared shall include any product thereof that gives off an inflammable vapor at a temperature of less than one hundred degrees of Fahrenheit's thermometer, shall be kept within fifty yards of a dwelling-house, or of a building in which goods are stored, except in pursuance of a license given by the local authority; and any petroleum kept in contravention of that section will be liable to forfeiture."

Petroleum Trade. — The rapid and extended use of American petroleum has no parallel in the history of manufactures or commerce. It was in August, 1859, that petroleum was first obtained in very considerable quantity in the valley of "Oil Creek," Pennsylvania; and since then the obtaining of the oil from the wells, the refining of it, and its transportation to markets, have continued to form a new and immense business. In the first nine months of 1861, the exports of American petroleum amounted to 368,940 gallons; while in the first nine months of 1862 the exports amounted to 6,294,819 gallons — an increase of 5,925,879 gallons. A circular recently issued by a leading oil-broker of Liverpool says: — "The oil exported from America and Canada in 1862 (the first year of its European introduction) exceeded in value £1,000,000. Yet one tithe of its dissemination is not effected; Britain has manipulated pretty freely, so have France and the German States, but so clamorous are they for more that the export extension cannot be made sufficiently general. Spain, Portugal, Italy, and Russia, have yet to receive it in the crude form."

WATER AS FUEL.

M. Moigno, the editor of the Paris *Cosmos*, describes the following application of steam, as having been witnessed by himself in a workshop in Paris. He says: —

It has long been known that when oxygen and hydrogen gases unite and form steam, as they do by their union, a most intense heat is produced. In this case, in fact, we have the oxyhydrogen blowpipe, which, though very small, is yet a furnace of most intense heat. It is now found that by exposing steam in its turn to a very high temperature, the atom of oxygen and the atom of hydrogen, of both of which, in union with each other, an atom of steam consists, tend to separate again, and in fact may be actually separated merely by presenting to the very hot steam some substance with which one of the elements of the steam either the oxygen or the hydrogen, tends to unite, rather than the other. But no sooner are the oxygen and hydrogen separate than they tend to rush together again, producing in the act of union the heat of the oxyhydrogen blowpipe. In order to obtain this wonderful power of heat, all that is necessary, as now appears, is to raise steam to a very high temperature, and then to let it loose, when very hot, upon some body which tends to unite with one of its elements, — its oxygen, for instance, — as is the case with common fuel. The hot steam immediately sets the fuel on fire. The heat that is produced is most intense, and there is reason to hope that the combustion may be so regulated that all the oxygen of the steam may reunite again with all the hydrogen of the steam, so that the whole result of the combustion shall be merely that the fuel is transformed by the intense heat into aeriform matter. And thus a furnace may be so arranged that while its heat is employed as usual in generating steam in a boiler for a steam engine, all the smoke shall be gas fit for illuminating purposes, and ready for being transferred into the gasometer. M. Moigno mentions that in the apparatus which he saw a jet of hot steam from a tube which was only one millimetre (about one twenty-fifth of an inch) in diameter, when made to play upon a mass of charcoal in a furnace, lighted it up into a most vivid fire. And when to the charcoal there were added a few handfuls of the Boghead mineral, which yielded bicarbonate of hydrogen instead of simple hydrogen, the light was dazzling, and the flame arose so as to sometimes reach the roof of the workshop. The only point that is staggering is the immense heat which is required to be imparted to the superheated steam. Thus, for the full effect 1,000° Cent. is named, that is, 1,832° Fah.; that is a heat at which silver and almost copper melts. And this is said to be produced by having the steam heater immersed in a bath of melted tin.

The *Revue Universelle* of Paris, of a later date, has also the following article respecting the use of water in facilitating certain processes of combustion. It says: "The vapor of water has already been utilized in metallurgy as an agent of oxidation in the roasting of certain minerals, particularly to facilitate the separation of the compounds of antimony and arsenic in metallic sulphurets. For several years attempts have been made to employ the calorific power of the hydrogen contained in water, and it is the same line of invention that Messrs. Maire and Valler have sought to utilize as a combustible in industrial furnaces, and particularly in metallurgic operations. Water, fed in a regulated and intermittent manner into a hot fire, is decomposed into oxygen and hydrogen. The combustion of the latter in presence of the atmospheric air (the oxygen of the water being employed in burning the carbon) produces a considerable heat in addition to that of the principal combustible. There results, then, a considerable augmentation of caloric without any addition of combustible, and consequently a more rapid fusion of metals and minerals, and an economy of fuel which the authors of the process state varies from forty to fifty per cent. Experiments and calculations have demonstrated that the heat absorbed by the decomposition of water is less than that furnished by the combustion of the gaseous products of the water decomposed.

CURIOUS OBSERVATIONS ON FERMENTATION.

The *Comptes Rendus* has recently published a *resumé* of M. Pasteur's researches on fermentation, from which we derive the following information: —

M. Pasteur began his investigations by experimenting on the vegetable organism known as the *mycoderma vini*, or the "*mother of wine*." Causing this plant to develop in various alcoholic liquids in contact with air, he never obtained acetic acid; and if he introduced a small portion of that acid, it usually disappeared. When the *mycoderma aceti*, or vinegar-plant, was grown in alcoholic liquids, acetic acid was always formed, with the intermediate production of small quantities of aldehyd.[1] In both cases the chemical phenomena and the life of the plants were clearly correlative. When the experiments were performed in close vessels, containing besides the liquid a known quantity of air, it was ascertained that the vinegar-plant took oxygen from the air, and therewith converted the alcohol into acetic acid; and that the mycoderm of wine took oxygen from the air, and converted the alcohol into water and carbonic acid. It was likewise ascertained that if the alcohol was removed, and the vinegar-plant grown in an acetic liquid, the acid was transformed into water and carbonic acid. With the mycoderm of wine the effect was the same, especially if there was a little alcohol in the liquid. From these facts M. Pasteur concludes that the wine and vinegar-plants behave in the same manner, and that there are circumstances in which their action is exalted; that is to say, that the plant, instead of taking from the air two or four molecules of oxygen to combine with one molecule of alcohol, and thus produce aldehyd or acetic acid, takes eight or twelve molecules of oxygen, and by their aid completely transforms the alcohol and the acetic acid into water and carbonic acid. The vinegar-plant does not produce acetification when it is submerged. This was ascertained by noting the degree of acidity of a liquid in which a growing plant floated. The plant was made to sink by glass rods, and the acetification was arrested. Following his investigations, M.

[1] "The alcohols may all be regarded as compound oxides of hydrogen, and of a peculiar hydrocarbon. . . . The alcohols, by imperfect oxidation, furnish *aldehyds;* and these bodies, by the further absorption of oxygen, yield acids."

Pasteur arrives at the conviction that the well-known process of manufacturing vinegar by allowing a suitable liquid to trickle over wood twigs or shavings, is not, as was supposed, a purely chemical process, but dependent upon the formation of a pellicle of the vinegar-plant. The important paper from which we have condensed these observations concludes in these words: "If the mycoderms possessed solely the property of acting as agents for the combustion of alcohol and acetic acid, their performance would be well worth attention; but I recognize in their functions a generality of action which opens a field for new researches in physiology and organic chemistry. In fact, the mycoderms are able to bring about the combustion of a great number of organic substances, such as sugars, organic acids, various alcohols, and albuminoid matters, giving rise in some cases to intermediate compounds, of which I have recognized a few. I may add that the property which we are discussing exists in various degrees among the mucidines, and I believe also among the smallest of the infusoria. I have observed that by the development of a mucidine it is possible to transform into carbonic acid and water considerable quantities of sugar, so that scarcely any of that substance shall be left in solution. If microscopic beings disappeared from our globe, its surface would be encumbered with dead organic matter and carcasses of all kinds, animal and vegetable. It is they who chiefly give to oxygen its combustion-producing qualities. Without them life would be impossible, for the work of death would be incomplete. After death, life reappears under another form, and with new properties. The germs, everywhere disseminated, of microscopic beings, commence their evolutions, and by their aid oxygen is combined in enormous masses with the organic substances, and their combustion gradually rendered complete. If I may be permitted to characterize briefly another point of view to which we have been conducted, I would say that we obscure the existence of organized cellules endowed with a property of completely burning organic masses with considerable evolution of heat, or of carrying their oxidation to a variable extent. This is a faithful image of the respiration and combustion which take place in the pulmonary cells through the circulation of the blood, whose globules seek oxygen from the air, in order that they may burn in various degrees the different principles of the human economy."

THE ORIGIN OF HONEY.

The following is an abstract of a paper on the above subject recently read before the Bristol (England) Microscopical Society, by W. W. Stoddard: — Although honey is a familiar body it is curious to note how little mention is made in any chemical or botanical work of the changes that take place in its elimination, of its origin, or even of its composition. Most chemical authorities simply state that the solid crystalline portion of honey is grape-sugar, but say nothing of the liquid. Johnson, in his *Chemistry of Common Life*, says "Honey is formed or deposited naturally in the nectaries of flowers, and is extracted therefrom by the bees. When allowed to stand for some time, it separates into a white, solid sugar, consisting of white crystals, and a thick, semifluid syrup. Both the *solid and liquid* *sugars have the same general properties.* The solid sugar of honey is identical with the sugar of the grape." Such is the drift of the whole information that can be gathered respecting the composition of honey.

On dissecting the honey-bee, we find the proboscis continued into a beautiful ligula or tongue. It is a flexile organ, covered with circlets of very minute hairs. The ligula of the honey-bee differs from that of the other divisions of the bee family (the Andrænidæ) both in shape and microscopic appearance. It is probable that the bee uses the ligula by inserting it in the nectar, which would be plentifully collected by means of the hairs before mentioned. These hairs very likely answer a somewhat similar purpose to the teeth of the molluscan tongue. At the base of the proboscis commences the œsophagus, which, after passing through the thorax, terminates in an expanded sac, termed the honey-bag. This is an elastic glandular organ, placed before the entrance to the true stomach. Into this sac the saccharine fluid enters after being swallowed. Should, however, any more solid substance be present, it is forwarded into the true stomach for trituration by the numerous teeth with which it is furnished. The honey-gland also secretes a peculiar acid to be mentioned presently. The bee retains the fluid portion in the honey-sac till the proper time should arrive for deposition in the cell of the honeycomb.

At the base of the corolla of a flower, on the thalamus, is a part termed by botanists "the disc." It is that portion which intervenes between the stamens and the pistil. It is composed of bodies usually in the shape of scales or glands. When examined at the proper season, they are seen to abound in a thick, sweet fluid, which, since the days of Aristotle and Virgil, has rejoiced in the name of "nectar." On this account the part yielding it received formerly the name of "nectary." Even in the present day those organs are the subject of much misapprehension. Linnæus and his followers gave the term nectary to any gland or organ for whose office they could not otherwise account. The plants which furnish the greatest quantity of nectar, and are therefore most liked by the bees, generally excrete it from the disc of the flower. On many plants, however, as the ranunculus and fritillaria, a small glandular organ occurs at the base of each petal, and in which also nectar is enclosed, though not in such profusion as in the disc before alluded to.

As will presently be shown, the nectar is a simple solution of cane-sugar formed from the amylaceous sap of the flower, and elaborated for the nutrition of stamens and pistil. What the bees find in the flowers is the surplus left when these organs have been supplied. The author examined every flower he could collect at the early season of the year (April and May), and found sugar in them all, whether furnished with discs, or nectariferous glands, or not; and came to the conclusion that sugar is necessary to the male reproductive organs of the flower, as it is in them chiefly to be found, the so-called nectariferous body merely serving the purpose of a reservoir.

The plants which in England are most attractive to bees are,—mignonette, currant, hazel, wallflower, hollyhock, raspberry, broom, rosemary, lime, buckwheat, clover, willow, gooseberry, lemon thyme, heath, turnip, osier.

On examining an immature blossom of a wallflower, the vessels will be found filled with an amylaceous fluid which gives a distinct blue with iodine. After the lapse of from twenty-four to forty-eight hours, the flower having become much more expanded and the stamens more mature, the fluid on being again tested will have a sweet taste, and give a dirty bluish-brown instead of a blue with iodine. On cutting out the discs of several ripe specimens of wallflower, the author obtained a syrupy, clear, colorless, fluid. This was mixed with a small quantity of distilled water, treated with lime and carbonic acid in the usual way, and filtered. The filtrate was then concentrated, and allowed to crystallize spontaneously on a glass slip. The result was a beautiful regular crop of crystals of cane-sugar.

As the flower became more mature, the saccharine fluid was acted upon by the vegetable acids more and more, until at length, when the ovary being fertilized, and the flower dead, a last examination showed the saccharine residue on the withered disc to be nearly all grape-sugar, almost incapable of being fairly crystallized.

The bee, visiting the flowers when in their prime, inserts its ligula into the blossom, and laps up the greater portion of the liquid sugar, which, after passing through the œsophagus, is deposited in the honey-sac. It here comes in contact with the secreting glands, which emit an acid which the author's experiments showed to be identical with formic acid. This it is which doubtless causes the peculiar tingling sensation at the back of the throat when much honey has been swallowed, and which is more perceptible to some than others. The bee after its arrival at the hive empties the contents of the honey-sac into the comb, where it remains until the store of honey is taken. When separated from the comb, the purest honey is a clear, thick liquid, which after standing becomes thicker, till at length it "sets," as it is technically called. A small bit of this, placed under a quarter of an inch objective, shows that this is owing to the grape-sugar (which has gradually been forming at the expense of the cane) crystallizing out in extremely thin, regular, six-sided prisms. All the cane-sugar is retained in the liquid portion of the honey. This crystallization proceeds as the whole of the cane-sugar becomes converted into grape. When this takes place, so great is the proportion of crystals that the honey is said to "candy," and is not considered so good from the presence of acetic acid, which is produced by the grape-sugar, which in its turn undergoes a change through the agency of fermentation. The honey crystals are not identical with those of cane-sugar.

On more closely examining a slide containing a bit of old honey, besides the prisms will be seen small bundles of crystals. These are manna-sugar. They remain after honey has been fermented, and may thus be separated. With these, small round or oval bodies will also be noticed spread over the field of the microscope, and are the pollen globules, showing in a beautiful manner from what flower the honey was collected. Of course they vary with every locality; but it is worthy of remark that a bee will only visit the same species of flower at the same journey; for the examination of a great number of bees will show that two kinds of pollen are never found on the same insect, although they may be very different on another working on the same flower-bed. A single bee, with all its industry, energy, and innumerable journeys it has to perform, will not collect more than a tea-spoonful of honey in a single season, and yet the total weight of honey taken from a single hive is often from sixty to one hundred pounds. A very profitable lesson of what great results may arise from persevering and associated labor!

The evidence on which the author relied for the presence of formic acid was by distilling the honey and receiving the distillate in an alkaline solution. The resulting solution, after decomposition by an acid and evaporation, afforded all the usual reactions, and readily reduced the salts of silver.

The foregoing facts, therefore, clearly show that—

First. Honey is derived simply from a solution of cane-sugar identical in every respect with that from the sugar-cane.

Secondly. That it afterwards receives the addition of a small quantity of formic acid from the glands of the bee.

Thirdly. That cane-sugar afterwards becomes gradually altered into grape-sugar by chemical decomposition. The flavor of honey is, of course, quite accidental, and dependent on the aroma of the flowers the bees have visited.

NEW METHOD OF PREPARING OZONE.

Bottger has given a method of obtaining ozone (—O) in comparatively large quantities and with great facility. He recommends a mixture of two parts pure, dry, finely-pulverized hypermanganate of potash in a flask, with three of pure sulphuric acid, of density 1.85, so that the liquid is opaque, and of a deep olive-green color. The mixture slowly evolves ozone at the ordinary temperatures. He finds the gas thus obtained one of the most powerful oxidizing agents yet known. Ether, alcohol and the ethereal oils burst into flame when brought into contact with a mere trace, and flowers of sulphur are instantly converted into sulphuric acid, the action being attended by an explosive noise.—*Journal für Prakt. Chem.*

APPLICATIONS OF ALUMINUM FOR CHEMICAL PURPOSES.

The lighter weights used for chemical purposes are now advantageously made of aluminum wire and foil, since, occupying something like seven times the space of those of platinum, they are more easily adjusted and handled, and less likely to be lost. The finest aluminum wire, from its insignificant weight, advantageously serves also to suspend, from the beam of the balance, objects the specific gravity of which it is desirable to ascertain.

THE DESULPHURIZATION OF IRON IN PUDDLING.

The inferior quality of bar iron obtained from the puddling of pig iron reduced from iron ores rich in sulphur, or even from good ores when reduced with coal containing much pyrites, is well known to ironmasters, and many methods have been devised for the desulphurization of this iron in the puddling process. Prof. R. Richter, of

Loeben, Austria, calling to mind the powerful oxidizing effect of litharge (oxide of lead), and its use to promote oxidation in many metallurgical processes, has experimentally proved that litharge will not only remove sulphur in the puddling process, but, what is equally important, it also oxidizes the phosphorus contained in the iron,—thus affording a most simple means of correcting two sources of greatest annoyance to the ironmaster.

PREVENTION OF WRITING FROM BEING EFFACED.

M. Sennefelder has published a curious process for rendering writing ineffaceable for purposes of fraud. It consists in dipping the paper on which a bill or check is to be written for a few seconds into a solution of gallic acid. When the paper is dry, it is fit to be used for writing on with common ink. Suppose any person were, with criminal intent, to endeavor to efface a word from the documents, he would either have recourse to the chloride of potash or the oxalate of potash for the purpose, and would find, to his dismay, that these substances produce a black ring or border round the characters, which it is impossible to efface without destroying the paper.

POTASH FROM THE ANIMAL KINGDOM.

The supply of potash has hitherto been solely derived from the vegetable kingdom. Recently, however, M. Maumené, a French chemist, has obtained it in considerable amount from animals. When sheep's wool is submitted to the action of cold soft water, a kind of greasy soap dissolves; this is a combination of certain fatty and oily acids with the alkali potash. It is found that, by heating this soap to redness, a very pure carbonate of potash is obtained. This process is so productive that it is worked as a commercial speculation at Rheims, and samples of the various potash salts were shown in the London Exhibition for 1862.

PARKESINE.

This name has been given by a Mr. Parkes, of England, to a material formed of collodion and castor oil, mixed with different proportions of coloring agents, resins, gums and earthy matters, according as it is desired to form plastic, flexible or hard materials, to be used for the manufacture of medallions, combs, knife-handles, etc. It is anticipated that the new material will supersede India-rubber in many of its applications.

MAGNETO-ELECTRICITY FOR THE REFINING OF IRON AND STEEL.

Mr. A. L. Fleury, of Philadelphia, who has continued his experiments (see *Annual Sci. Dis.*, 1862, pp. 105–6) of applying electricity for the refining of iron and steel, communicates to the editor the following *resumé* of new results:—

"Experimenting with one of Baker's largest size magneto-electric machines (so arranged as to give a broken and rapidly-reversed intensity current) on cast iron, while about to consolidate in the mould, I found that the metal thus treated had acquired a much closer grain, lighter color, and had become exceedingly strong when compared with iron that had been poured at the same time into a similar mould and from the same mass. The same effect I also produced on steel, when, immediately after casting and previous to its consolidation, an interrupted and rapidly-reversed intensity current of electricity was passed through the same.

"The violent pulsations of intensitive electricity, the rapid changes of polarity, prevented the growth of larger crystals; they contracted, and in some respect changed the molecular structure of the metal.

"Another valuable feature attended the application to steel, namely, that after breaking the bar of steel no honey-combs, as the air-cavities that usually appear in cast steel are called, could be detected. For large castings, for instance of ordnance, steam cylinders, etc., the application of electricity may become of great importance; the use of the magneto-electric machine, moreover, requiring nothing but the adjustment of a belt, reduces the expense for the electric force to a very small figure."

OZONE PRODUCED BY PLANTS.

M. Kosman has communicated to the French Academy a series of observations, from which he draws the following conclusions:— 1. Plants evolve ozonized oxygen from their leaves and green parts. 2. They disengage, during the day, ozonized oxygen in a greater ponderable quantity than exists in the circumambient air. 3. During the night the difference between the ozone produced in the plants and that contained in the air becomes *nil* in the case of isolated vegetation, but where the plants grow thickly and vigorously this ozone is more abundant than that of the air. 4. Plants in the country evolve more ozone during the day than town plants. 5. From this cause country air is more exhilarating than town air. 6. In the midst of towns, and of a dense population, the night air exhibits more ozone than that of the day, but in proportion as the animal population diminishes, and the vegetable kingdom predominates, the diurnal ozone increases until it exceeds that of the night. 7. The interior of the corollas of plants do not evolve ozone. 8. Inhabited rooms do not usually contain ozonized oxygen.

GEOLOGY.

LIFE CHANGES ON THE GLOBE.

It has generally been assumed by geologists that, through the similarity of fossil remains existing in analogous formations in different countries, we were put in possession of the means of establishing a comparative chronology universally applicable in our mundane world. The age, for example,—giving geological latitude to the word,—of Silurian slates and sandstones, coal measures, or chalk, was supposed to be the same all over the globe. If the characteristic fossils were found, they were presumed to decide the epoch to which the strata belonged, and few geologists, even in the recesses of their own minds, ventured to question the dogmas of a scientific orthodoxy which were not without convenience in application, and which were widely received. In a recent communication to the London Geological Society, Prof. Huxley assails the grounds of this belief, and enters into an inquiry as to the nature of the evidence on which assumptions in geology, generally considered as fundamental, are based. The first of these assumptions is, that the commencement of [that part of] the geological record [which has hitherto been deciphered] is coeval with the commencement of life on the globe; and the second, that geological contemporaneity is the same thing as chronological synchrony. Without the first of these assumptions, says Prof. H., there would of course be no ground for any statement respecting the commencement of life; and, without the second, all statements implying a knowledge of the state of different parts of the earth, at one and the same time, will be no less devoid of demonstration.

The first assumption obviously rests entirely on negative evidence. This is, of course, the only evidence that ever can be available to prove the commencement of any series of phenomena; but, at the same time, it must be recollected that the value of negative evidence depends entirely on the amount of positive corroboration it receives. If A B wishes to prove an *alibi*, it is of no use for him to get a thousand witnesses simply to swear that they did not see him in such and such a place, unless the witnesses are prepared to prove that they must have seen him had he been there. But the evidence that animal life commenced with the Lingula-flags, *e. g.*, would seem to be exactly of this unsatisfactory, uncorroborated sort. The Cambrian witnesses simply swear they "haven't seen anybody their way;" upon which the counsel for the other side immediately puts in ten or twelve thousand feet of Devonian sandstones to make oath they never saw a fish or a mollusc, though all the world knows there were plenty in their time.

Having thus defined the nature of his inquiry, Prof. Huxley shows that when the lias of England and that of Germany, or the cretaceous rocks of Britain or of India, are said to be "contemporaneous," the word is most loosely employed, and that no evidence exists by which synchronism of formation can be demonstrated in either case. Taking for an illustration the computation of the late Daniel Sharpe that thirty or forty per cent. of the known Silurian mollusca are common to both sides of the Atlantic, and by way of allowance for undiscovered specimens assuming that sixty per cent. are common to the North American and British Silurians, he avers that if contemporaneity or synchronism were assumed upon such evidence, we should fall into serious mistakes: —

"Now suppose that a million or two years hence, when Britain has made another dip beneath the sea and has come up again, some geologist applies this doctrine, in comparing the strata laid bare by the upheaval of the bottom, say of St. George's Channel, with what may then remain of the Suffolk Crag. Reasoning in the same way, he will at once decide the Suffolk Crag and the St. George's Channel beds to be contemporaneous, although we happen to know that a vast period (even in the geological sense) of time, and physical changes of almost unprecedented extent, separate the two.

"But if it be a demonstrable fact that strata containing more than sixty or seventy per cent. of species of Mollusca in common, and comparatively close together, may yet be separated by an amount of geological time sufficient to allow of some of the greatest physical changes the world has seen, what becomes of that sort of contemporaneity, the sole evidence of which is a similarity of facies, or the identity of half a dozen species, or of a good many genera?

"And yet there is no better evidence for the contemporaneity assumed by all who adopt the hypotheses of universal faunæ and floræ, of a universally uniform climate, and of a sensible cooling of the globe during geological time."

Looking fairly at the evidence before us, we can only come to the conclusion that "a Devonian fauna and flora in the British Islands may have been contemporaneous with Silurian life in North America, and with a carboniferous fauna and flora in Africa." What *was* the case we have as yet no means of knowing, and while grounds of decision are wanting judgment should hold suspense. If we may compare the successive changes in various parts of the globe to the movements of a clock, we must not assume the starting-point of any series of operations to have been identical. Each country, so to speak, may have had its own clock, — all the clocks going upon the same principle, and to a large extent with the same order in their motions, but the dawn marked by one may correspond in actual time with the noon or the evening of another place.

The extreme value so often assigned to negative evidence has materially assisted spasmodic theories. It has led to the unproved and improbable assumption that our very limited search for the remains of older periods enables us to decide authoritatively the proximate periods at which fish, reptiles, or mammals were introduced, and it has also induced many authorities to affirm in the most positive manner that the organized beings of two epochs have been *totally* distinct. As an instance of this common phraseology we may cite a recent declaration that in Australia, as in Europe, "the greater part of the country sank under the sea during the Tertiary period, and *every trace* of the previous creations of plants and animals were destroyed, and replaced by a *totally different set.*"[1] This violence of expression may be justified; but let us call to mind Sir C. Lyell's remarks in 1851,[2] in reference to the dredging operations of Messrs. Forbes and MacAndrew between the Isle of Portland and the Land's End. During one hundred and forty dredgings, at various distances from the shore, they obtained a large quantity of marine invertebrates, but very few traces of vertebrate life; none of them referable to terrestrial animals. "If," says Sir Charles, "reliance could be placed on negative evidence, we might deduce from such facts that no cetacea existed in the sea, and no reptiles, birds, or quadrupeds on the neighboring land."

In comparing the fauna and flora of the two periods, or of two contemporaneous countries, the amount of agreement or difference which an observer will trace must depend very much upon the method he employs. If he is a profound believer in certain systems of classification, he may affirm objects to be totally distinct, or new creations, and so forth, while they are closely allied; and if we consider the pernicious influence of spasmodic theories in blinding the mind even to obvious facts, it is consoling to find so great an authority as Prof. Huxley confirming opinions which are in conformity with the most probable deductions from general science. He tells us that if we leave negative differences out of consideration, and regard the fossil world in the broad spirit suggested by comparative anatomy, we shall be struck with "the smallness of the total change." Out of "two hundred known orders of plants, not one is certainly known to exist exclusively in a fossil state. The whole lapse of geological time has as yet not yielded a single new ordinal type of vegetable structure." In the animal world the change has been greater; but still "no fossil animal is so distinct from those now living as to require to be arranged even in a separate class from those which contain existing forms. It is only when we come to the orders, which may be roughly estimated at about a hundred and thirty, that we meet with fossil animals so distinct from those now living as to require orders for themselves; and these do not amount, on the most liberal estimate, to more than about ten per cent. of the whole."

Our limited space prevents further extracts from Prof. Huxley's paper, but the notice above given will show the nature of the views taken by him, and call attention to their importance.

RELATIONS OF DEATH TO LIFE IN NATURE.

All life is a system of progressive change in cycles, — the germ first, then the embryo, the young, the adult, and, last, the seed or germ again, to continue the rounds; the adult sooner or later disap-

1 *Annals of Natural History*, Feb., 1862, p. 144.
2 *Quarterly Journal of the Geological Society*, May, 1851, p. 53.

pearing from the field of progress, and then from the sphere of existence. Death is implied in the very inception of the scheme.

2. Death is also in every step of the process of life. For the living being is throwing off effete matter during all its growth. The change is constant, so that with each year a large part of the material in our bodies has passed away and been replaced by new. Moreover, the force which had been expended in making a cell or particle of tissue goes to form a new cell or particle when the former dies, and was needed for the new formation going on. Force is not lost or wasted, but used again. There is unceasing flow, and in this flow is life; its cessation is death.

3. The kingdom of plants was instituted to turn mineral matter into organic, that the higher kingdom of animals might thereby have the means of sustenance; for no animal can live on mineral matter. Now this living of animals on plants implies the death of plants.

Again, the rocks of the globe are, to a great extent, made of the remains of dead animals.

4. The chemistry of life, also, required death. Life in the plant or animal, if sustained by means of nutriment, and continued consuming, with no compensating system, would evidently end in an exhaustion of any finite supply. A perfect adjustment was therefore necessary, by which nutriment should sustain life, and life contribute to nutriment. Now the plant takes up carbonic acid from the atmosphere, appropriates the carbon, and gives back the oxygen. Yet there is no tendency to an exhaustion of the atmospheric carbonic acid, or an over-supply of the oxygen; for death strikes an exact balance.

The death of a plant ends in a change of all its carbon into carbonic acid again. Thus the plant, as it grows, decomposes carbonic acid to get carbon, and then ends in making, in its decay, as much carbonic acid, and restoring it to the atmosphere. Thus through death the compensation is perfect. The atmosphere loses only what it receives. Again, as just now observed, the plant, in growing, gives oxygen to the atmosphere; but in the decay of the plant the carbonic acid formed is made by taking up the same amount of oxygen. The same carbon that lost oxygen when becoming a part of the plant, takes it again at the decay. The system is hence complete. The parts play into one another in perpetual interchange. Take death and decay out of the system, and it would not work.[1]

Animal life, as above stated, was made to subsist on plants. But the scheme is so well managed as not to disturb the balance made by the vegetable kingdom alone. For all the carbon of animals comes from plants. The plants which feed an animal, and which, on decay, would have turned into carbonic acid, become changed into carbonic

[1] In early geological history, as is generally believed among geologists, there was an excess of carbonic acid in the atmosphere; and this excess was removed, to a great extent, by the growth of plants during the carboniferous era. Vegetable material decaying under water does not undergo complete decomposition, and thus part of the carbon is left behind; and so far as there is carbon left, there is an actual abstraction of carbonic acid from the atmosphere, by the process of growth. The coal era was a period of great marshes; and by this means the needed purification of the atmosphere was effected, preparing it for land life. The amount abstracted now by the same means is very small, and may be balanced by the carbonic acid from mineral sources and volcanoes.

acid in the course of the growth of the animal, so that the whole amount of carbonic acid which the animal makes is only what the plants would have made if left to natural decay. Thus the higher kingdom of life is introduced and sustained, and yet the balance remains undisturbed. The system is perfect.

5. Again, one part of the animal kingdom, through every class, is made to eat up the other part, or at least live on it. The flesh-eaters are of all grades, low and high, from the infusorium and maggot to the lion and man. Some take what is already dead or decomposing; others kill and eat. On this subject we observe: —

(1.) Death is in the system of nature, — death from earthquake, lightning, and all moving forces, as well as by natural decay; and the creation of carnivorous animals was hence in harmony with the system.

(2). Various noxious animals are held in check by the carnivorous species.

(3.) By means of flesh-eaters, the diversity of animal species subsisting on a given amount of vegetation is vastly increased, and a wider expansion is given to the animal kingdom.

(4.) Putrefaction of the dead is prevented by a multitude of scavengers, who at the same time turn the flesh into food for the vegetable kingdom; and thus plants feed animals, and animals feed plants, — one of nature's circles again.

The last two principles mentioned are of profound importance. The vegetable kingdom is a provision for the storing away or magazining of force for the animal kingdom. This force is acquired through the sun's influence or forces acting on the plant, and so promoting growth; mineral matter is thereby carried up to a higher grade of composition, — that of starch, vegetable fibre, and sugar, — and this is a state of concentrated or accumulated force. To this stored force animals go, in order to carry forward their development; and, moreover, the grade of composition thus rises still higher, to muscle and nerve (which contain nitrogen in addition to the constituents of the plant), and this is a magazining of force in a still more concentrated or condensed state. There are thus five states of stored force in nature, — three in the *inorganic*, the solid, liquid, and gaseous; and two in the *organic*, the vegetable and animal.

Now what is the provision to meet this last and highest condition? Is this magazined force left to go wholly to waste by the death and decomposition of plant-eaters? Just the contrary. An extensive system of flesh-eaters was instituted, which should live upon it, and continue it in action in sustaining animal life among successive tribes. The flow is taken at its height, and the power is employed again and again, and made gradually to ebb. What is left as the refuse is inorganic matter, — the excreted carbonic acid, water, and excrements, with bones or any stony secretions present. Thus the flow starts at the inorganic kingdom, and returns again to the inorganic. Moreover, in the class of quadrupeds (mammals), the flesh of the herbivores (cattle) is among the means by which the animal type is borne to the higher grade of the carnivores. The true carnivores, besides, take the best of meat. Whales may live on the inferior animals of the sea; but the large forest flesh-eaters take beef and the like.

There is another admirable point in this scheme. The death and decomposition of plant-eaters would have rendered the waters and air, locally at least, destructive to life. It is well known that it is necessary in an aquarium to have flesh-eaters along with the plant-eaters and plants. And when in this way the living species are well balanced, the water will remain pure, and the animals live on indefinitely. If not so balanced, if an animal is left to decay, the waters become foul, and often everything dies. Putrefaction and noxious chemical combinations follow death, because, in life, the constituents, carbon, hydrogen, nitrogen, and oxygen are in a constrained state, at the furthest remove from what chemical forces alone can produce; and hence, when the restraint is taken off at death, the elements fly into new conditions according to their affinities. Now animals, dying yearly by myriads, are met at death by an arrangement which makes the dead contribute anew to animal life as its aliment, and in this very process the flesh ultimately comes out innocuous, and is at last so far changed to the inorganic condition as to be the best fertilizers of plants. Part of the process of getting rid of the great fleshy carcasses consists in their minute subdivision by the feeding of larves of insects, and, further, an infinitesimal division of the insect as the food of the infusoria, — which again may become the nutriment of larger animals, to go the rounds once more. But the final result is, as stated, *plant-food*, — largely through the processes of digestion and excretion, but part through the decomposition of animals that are too small and readily dried up to prove offensive.

Thus the carnivorous tribes were necessary to make the system of life perfect.

One word respecting the necessity of a check on the excessive multiplication of individuals. Nature, as just now observed, is a system of constantly varying conditions, — of changing seasons, winds, clouds; of inconstancy, under law, in all forces and circumstances. At the same time, the growth of a species requires the nicest adjustment of special conditions in each case. On this account the reproductive powers in species is in many cases excessively large, so that the various accidents to which the eggs or young would be exposed might not cause their extermination. This provision opened the way for occasional excessive multiplication, and required a check from carnivorous races.

(5.) Finally, could death be prevented in a system of living beings in nature without constant miracles? How should the earth be managed to secure it against death? It would be necessary to still the waves, for they are throwing animals and plants on the coast to die; to still the winds, for they are ever destroying in some parts of their course; to still even the streams and rains. With winds and waves, not only helpless animals and plants, but men's houses, ships, and boats would now and then be destroyed, in spite of prudent precaution and holy living. But if we still the waves, the winds, and the streams, the earth would rot in the stagnation, and here again is death!

We thus learn, that in life the fundamental idea of reproduction implies death; the processes of life are the processes simultaneously of death; the stability of the system of life requires death; the vegetable kingdom is made to feed animals, and the animal kingdom, while containing plant-eaters, demands flesh-eaters for its own balance, for the removal of the dead, and to make out of dead flesh the proper food for plants, thus to pay its debt to the vegetable kingdom. Hence death pervades the whole system of life in its essence and physical laws; and it could not be prevented in a world of active forces except by a constant miracle; and this would be an annihilation of nature, that is, of a system of law. — *Prof. J. D. Dana, Silliman's Journal.*

THE SALTNESS OF THE SEA.

In the course of the last twenty years the distinguished Danish chemist, Forchhammer, has executed about two hundred complete analyses of water from all parts of the ocean, but in particular from the Atlantic and the north European seas connected with it. At the eighth meeting of the Scandinavian naturalists, at Copenhagen, the important results of these laborious researches were communicated.

Saltness of the Ocean. — The mean of 140 complete analyses gives 34.304 of salt in one thousand parts of water, unequally distributed over 16 regions. But the specimens being principally taken at lower latitudes, this mean is too high. If we take 34 in one thousand parts as the mean saltness of the sea at the mean atmospheric pressure, and give the results in differences of ten thousandths from this mean, they will become more perspicuous.

Thus the mean saltness of the Atlantic (35.77 thousandths) is expressed by + 17.7; of the California Pacific + 12.2, Japanese Pacific + 4.3, Indian Ocean + 1.3. The Atlantic system of rivers drains by far the greater portion of the continents, and has the same position in latitude; thus the evaporation in the Atlantic must be greater than in any other part of the ocean.

The Atlantic is divided into five regions, viz: —

Reg.	III. Arctic region,	mean	of	16	analyses,	+ 15.6
"	II. North temperate,	"	"	24	"	+ 19.5
"	I. North tropical,	"	"	14	"	+ 21.7
"	X. South tropical,	"	"	6	"	+ 24.7
"	XI. South temperate,	"	"	6	"	+ 10.4
"	XVI. Antarctic Ocean,	"	"	1	"	— 54.4

Thus the tropical part of the Atlantic is the saltest, and the amount of salt regularly decreases toward the poles; yet the northern Atlantic is more salt than the southern (an influence of the Gulf Stream).[1]

The first great circulation of terrestrial water is represented in these numbers: only a part of the water evaporated between the tropics directly returns to land and sea in form of rain; another part is carried to the polar regions, here condensed to snow and ice, returning toward the equatorial belt either in great fresh-water currents or in veritable ice-streams, thus reëstablishing the equilibrium.

Saltness of Oceanic Currents. — The equatorial current has in the Bay of Benin a saltness of + 3.8; crossing the equator between long.

[1] The maximum of saltness, + 29, or 37.908 thousandths, is in the north tropical part of the Atlantic, opposite the dry coasts of Sahara, whence hot, dry winds, but no fresh water may be obtained, lat. 24° 13′ N., long. 23° 11′ W.

25° and 35° W., this successively increases by evaporation to + 17.3 and + 20.8. On the same longitude, at lat. 15° S., the saltness is + 31.5, lat. 12–14° N. + 21.9 and 19.4; thus the current is less salt than the ocean near it — indicating the freshening influence of the great rivers of Guinea. Near St. Thomas, West Indies, the saltness is only + 17, — the enormous amount of fresh water from the Amazon and Orinoco reaching thus far, since a few degrees north of the current the saltness of the ocean is again + 27. At the Bermuda Islands the saltness is + 18.8 — the evaporation in the Gulf has been counterbalanced by the waters of the Mississippi. Northward the Gulf Stream increases to 21.0, 22.8, and 23.6; but at lat. 43° 26′, long. 44° 19′ W., where the St. Lawrence empties, the saltness abruptly sinks to + 1.5 (a diminution of $2\frac{1}{2}$ thousandths!) From this minimum it slowly rises to + 18.9, and at last diminishes again in the higher latitudes. *These regular oscillations in the saltness of the great Atlantic current show the fresh water supply obtained from the great African and American rivers, and the effects of evaporation, and make it very probable that these rivers contribute to give the current its particular direction.*

The mean saltness of the polar current of Baffin's Bay is + 8.2, but decreasing towards the north,

Latitudes,	58° 53′	64°	69°
Saltness,	+ 15.8	+ 10.3	+ 4

showing how the water of the Arctic Sea is freshened by the northern rivers, Greenland glaciers, and the Hudson's Bay rivers.

The saltness of about twenty points of the ocean has been determined for different depths. A difference of about one thousandth corresponds to the greatest depth observed, lat. 12° 36′ N., long. 25° 35′ W., depth 11,100 feet. The saltest water of the surface here evidently is the hottest.

In Davis Strait and Baffin's Bay no considerable difference of saltness for different depths is observed; but in the adjacent Atlantic the lower water is less salt than the warmer above it; and this same cold and less salt bottom current may be traced along the Atlantic, except where great quantities of fresh water are introduced by European and American rivers, making the lower strata the saltest.

In the Indian and Pacific the lowest water everywhere seems to be the saltest (only four observations).

Composition of the Salts. — Twenty-five different elements have been observed in the salt of the ocean or in plants and animals of the sea: *O*, *H*, *Cl*, *Br*, I, Fl, *S*, P, *C*, N, Si, Fe, Mn, *Mg*, *Ca*, Sr, Ba, *Na*, *Ka:* Ag, Cu, Pb, Zn, Co, Ni; but only those printed in *Capitals* are predominant. Of these, chlorine, sulphuric acid, lime, and magnesia, may be determined with great exactitude. Comparing all analyses of *ocean water* (including the North Sea), it is found that the relative proportion of the components is nearly constant, being —

Chlorine 100, sulphuric acid 11.91, lime 2.95, magnesia 11.08. Total 181.1 (for each 100 of chlorine).

The total is the most constant; yet there are small but constant differences for the different regions of the ocean — differences enlarging with the proximity of land, greatest in gulfs and bays. — *Silliman's Journal.*

NOTES ON THE SURFACE GEOLOGY OF THE BASIN OF THE GREAT LAKES. BY DR. J. S. NEWBERRY.

The changes which have taken place in the physical geography of the country surrounding the great lakes, geologically speaking, within a recent period, have been very great; how great, and dependent upon what causes, we cannot as yet definitely state, as much more study than has hitherto been given to the subject will be necessary before all its difficulties and obscurities shall be removed. These changes to which I have referred apparently include (a) great alterations in the level of the water-surface in the lake basin, and (b) in the elevation of this portion of the continent as compared with the sea-level, with (c) corresponding alternations of temperature, all followed by their natural sequences.

The facts which lead to these conclusions are briefly as follows: —

(1) The surfaces of the rocks underlying all portions of the basin of the great lakes, except where affected by recent atmospheric action, are planed down, polished, scratched, and furrowed, precisely as those are which have been observed beneath heavy sheets and masses of moving ice. The effect of this action is strikingly exhibited in the hard trap ledges of the shores of Lake Superior; by the *roches moutonnés* of the granitic islands in the St. Mary's River and Lake Huron; by all the hard, rocky margins of Lake Huron and Lake Michigan; by nearly all the surface rocks, when hard enough to retain glacial furrows, of Ohio, Indiana, Illinois, Iowa, Wisconsin, etc.

(2) Upon these grooved and polished surfaces we find resting, —

First, *A series of blue laminated clays* in horizontal beds, containing few shells, as far as yet observed, but, in abundance, water-worn trunks of coniferous trees with leaves of fir and cedar, and cones of a pine. Second, *Yellow clays, sands, gravel, and boulders.* Among the latter are granite, trap, azoic slates, silurian fossiliferous limestone, masses of native copper, etc., all of northern origin, and generally traceable to points several hundred miles distant from where they are found.

(3) Millions of these granite boulders and masses of fossiliferous limestones, often many tons in weight, are now scattered over the *surface* of the slopes of the highlands of Ohio; and, in some places, collections of them are seen occupying areas of several acres, and numbering many thousands, all apparently having been brought here together and from one locality.

(4) At various points are found remarkable pits, conical depressions in the superficial deposits, which have been attributed to icebergs stranding and melting, dropping their loads of gravel and stone around their resting-places.

(5) The beds of clay and other transported materials mentioned above are several hundred feet in thickness, extending from at least one hundred feet below the present water level in the lakes to points five hundred feet or more above that level.

(6) During the "glacial period" to which I have referred, the whole country must have been relatively higher than at present, and the drainage much more free; for, during this epoch, the valleys of

the streams were excavated to a far greater depth than they are at present. This is proven by the explorations which have been made in all the country bordering Lake Eric in search of rock oil. The borings made upon the Upper Ohio and its tributaries, as well as along the rivers emptying into Lake Erie, show that all these streams flow above their ancient beds, — the Mahoning and Shenango, at their junction, one hundred and fifty feet; the Cuyahoga, at its mouth, over one hundred feet above the bottom of their rocky troughs. The valley of the Mississippi at St. Louis and Dubuque, and the Missouri at and above Council Bluffs, exhibit precisely similar phenomena, — deep troughs excavated in the rock by the ancient representative of the present streams, subsequently submerged and filled up with drift clay, gravel, or loess; these troughs having been but partially cleared of these accumulations by the action of the rivers during what we call the present epoch.

(7) Along the margins of the great lakes are distinct lines of ancient beaches, which show that in comparatively recent times the water level in these lakes was full one hundred feet higher than at present.

The facts enumerated above seem to justify us in the following inferences in regard to the former history of this portion of our continent. (A) At a period corresponding with, if not in time, at least in the chain of events, the glacial epoch of the Old World, *the lake region, in common with all the northern portion of the American continent, was raised several thousand feet above the level of the sea.* In this period the fiords of the Atlantic (and probably Pacific) coasts were excavated, as also the deep channels of drainage which, far above their bottoms, are traversed by the Mississippi and its branches, and indeed most of the streams of the lake country.

During this period Lake Erie did not exist as a lake, but as a valley, traversed by a river to which the Cuyahoga, Vermillion, Chagrin, etc., were tributaries. In this "glacial epoch" all the lake country was covered with ice, by which the rocky surface was planed down and furrowed, and left precisely in the condition of that beneath the modern moving glaciers in mountain valleys. Could we examine the surfaces upon which rest the enormous sheets of ice which cover so much of the extreme arctic lands, we should doubtless find them exhibiting the same appearance.

(B) *At the close of the glacial epoch all the basin of the great lakes was submerged beneath fresh water, which formed a vast inland sea.*

From the waters of this sea were precipitated the laminated clays, the oldest of our drift deposits, containing trunks and branches of coniferous trees, a few fresh-water and land shells, but no oceanic fossils. Parallel beds on the St. Lawrence generally contain marine remains. It would seem, then, that this was a period of general subsidence throughout the northern portion of our continent, and that the Atlantic then covered a large part of New England and Canada East.

(C) *Subsequent to the deposit of the blue clays, an immense quantity of gravel and boulders was transported from the region north of the great lakes, and scattered over a wide area south of them.*

That these materials were never carried by currents of water is certain, as their gravity, especially that of the copper, would bid defiance to the transporting power of any current which could be driven across the lake basin; indeed, that such was not the method by which they were carried is conclusively proved by the fact that, between their places of origin and where they are now found, the blue clay beds previously deposited now lie continuous and undisturbed. By any agent, ice or water, moving over the rocky bottom of the lake basin, carrying with it gravel and boulders, these clay beds would have been entirely broken up and removed. The conclusion is, therefore, inevitable that these immense masses of northern drift were *floated* to their resting-places. All the facts which have come under my observation seem to me to indicate that, during countless years and centuries, icebergs freighted with stones and gravel were floating from the northern margin of this island sea, melting and scattering their cargoes on or near its southern shores. Subsequently, as its waters were gradually withdrawn, these transported materials, rolled, comminuted, and rearranged by the slowly retreating shore waves, were left as we now find them, heaps and imperfectly stratified beds of sand and gravel.

(D) In the lake ridges (ancient beaches), we have evidence that the water of the lakes remained for considerable intervals much higher than at present. By careful study of these ridges we may hereafter be able to map the outlines of the great inland sea, of which our lakes are now the miniature representatives, and to determine by what causes, whether by local subsidence of some portion of its shores, or the cutting down of channels of drainage, this great depression of the water level was effected. If, with the topography of the basin of the lakes remaining precisely what it now is, the water level were raised one hundred feet, to the ancient beach which runs through the city of Cleveland, the whole of the chain of lakes would be thrown togther and form a great inland sea. By this sea a large portion of the State of New York would be submerged, much of Canada lying in the basin of the St. Lawrence, most of the peninsula of Canada West, the greater part of Michigan, and a wide area south and west of the lakes in the States of Ohio, Indiana, Illinois, Wisconsin, etc. Indeed, raised to this level, the water of the lakes would submerge deeply the summit between Lake Ontario and the Mohawk, and escape at once through the Hudson to the ocean, as well as by the outlet of the St. Lawrence. At the West a similar state of things would exist; the Kankakee summit, the divide between Lake Michigan and the Mississippi, now scarcely more than twenty feet above the lake level, would be deeply buried, and the whole valley of the Mississippi flooded. We apparently have proof that the lake waters *did* once flow over this summit, as it is said that lake shells are found beneath the soil over nearly all parts of it.

While it is entirely possible that the low points in the rim of this great basin have been worn down to the present inconsiderable altitude by the action of the water flowing from it, and that the former inland sea was drained by the simple process of the wearing down of its outlets, we may well hesitate to accept such an explanation of the phenomena until conclusive evidence of its truth shall be obtained.

Geological history affords us so many examples of the instability of our *terra firma*, that we can readily imagine that local changes of level in the land have not only greatly affected the breadth of water surface in the lake basin, but have perhaps in some instances produced what we have supposed to be proofs of great and general elevations of the water level, which are, in fact, only indications of a local rise of the land.

THE GLACIAL ORIGIN OF LAKES.

In a paper recently read before the Geological Society (London), Professor Ramsay gave reasons for considering that the great Alpine lakes, such as Geneva, Zurich, Constance, Maggiore, Lugano, Como, and others, "do not lie among the strata in basins merely produced by disturbance of the rocks, but in hollows due to denuding agencies that operated long after the complicated foldings of the miocene and other strata were produced." He remarked that none of these lakes lie in simple synclinal troughs, and that in no case of lakes among the Alps is it possible to affirm that we have a synclinal hollow, of which the original uppermost beds remain; neither do they lie in areas of mere watery erosion. Neither running water nor the still water of lakes can scoop large hollow basins, like those of the lakes, bounded on all sides by rocks. Running water may fill them up, but cannot excavate them. Prof. Ramsay next argued that these lakes do not lie in lines of gaping fracture. A glance shows this, with respect to such lakes as those of Geneva, Neuchatel, and Constance; and, reasoning on the nature of the contortion of the strata of the Alps, he contended that, though fractures of the rocks must be common, they need not be gaping fractures. To produce such a mountain chain, the strata are not *upheaved and stretched* so as to produce open cracks; on the contrary, they are *compressed laterally and crumpled up* into smaller space, and the uppermost strata, that pressed heavily on the crumpled rocks now visible, would prevent the formation of wide, open fractures below, these upper strata, as in North Wales, having, over a great part of the area, been mostly or altogether removed by denudation. Next, lakes of the rock-basin kind do not lie in an area of special subsidence. If so, for instance, we should require one for the Todten Sea, one for the Grimsel, one for the ancient lake of the Kirchet, several at the foot of the Siedelhorn, many hundreds close together in Sutherlandshire (England), and thousands in North America.

If, then, the lake-basins were formed by none of the above-named causes, the only other agent that has affected the country on a great scale is glacier ice. All the lakes lie directly in the courses of the ancient glaciers. The basin of the Lake of Geneva is 950 French feet deep near its eastern end, and was scooped out by the great glacier of the Rhone, the ice of which, from data supplied by Charpentier, was about 1,200 feet thick when it abutted upon the mountains, and 2,780 feet thick when it first flowed out upon the plain at the mouth of the valley. Add to this the depth of the lake of 984 feet, and the total thickness of the ice must have been 3,764 feet at what is now the eastern part of the lake. "I conceive, then," says Prof. Ramsay, "that this enormous mass of ice, pushing first north-west, and then partly west, scooped out the hollow of the Lake of Geneva most deeply in its eastern part, opposite Lausanne, where the thickness and the weight of ice, and consequently its grinding power, were greatest."

The lakes of Thun and Brienz lie in the course of the great Aar glacier, those of Zug and the Four Cantons in that of Altorf, the Lake of Zurich lies in that of the Linth, the Lake of Constance in the course of the prodigious glacier of the Rhine valleys, the numerous little rock-basin lakes near Ivrea in the line of the glacier of the Val d'Acosta, and those of Maggiore, Lugano, and Como, in the courses of the two gigantic glacier-areas that drained the mountains between Monte Rosa and the Sondrio.

The sizes of the lakes and their depths were then shown to be, in several cases, proportional to the magnitude of the glaciers that ground out the basins in which they lie, and to the circumstances whether the pressure of ice was broadly diffused, or vertical as in narrow valleys.

Finally, it was shown that rock-basins holding lakes are always exceedingly numerous in and characteristic of *all countries that have been extensively glaciated.* Lakes are comparatively few in the southern half of North America, but immediately south and north of the great lakes and the St. Lawrence the whole country is *moutonnée* and striated, and is also covered with a prodigious number of rock-basins holding water. The same is the case in the north of Scotland, the whole area of which has been *moulded by ice;* and east of the Scandinavian chain, in another intensely glaciated region, the country is covered by innumerable lakes.

THE ORIGIN OF THE EXTERNAL FEATURES OF THE LAND.

In a paper on the above subject presented to the British Association, by Prof. Jukes, President of the Geological Section, the author asked, in the first instance, how the variations of the surface called mountains, hills, cliffs, glens, valleys, and plains, were formed. He took, first, the formation of great plains, and showed that although some were formed as plains on horizontal beds, few even of these retained the original surface of the position, but had more or less a denuded surface. Many equally level plains were low and level because mountainous masses of rock, often greatly disturbed and contorted, had been removed from above the present surface. The central plain of Ireland, and other plains in the British Islands, were formed in this way. All mountains, except volcanoes or "hills of ejection," were either "hills of circumdenudation," formed by the wearing down and removal of the rocks formerly around them, or "hills of uptilting." In the latter, the lowest rocks appeared in the central parts of the chain, often reared into the highest peaks, and these central beds dip on either hand under higher and higher groups, which come in as we recede from the axis of the chain. The beds have been raised by mechanical force acting from below; but this, however it had tilted or bent them, could not remove them, so that the successive exposure of lower and lower beds as we approach the axis of the chain must be owing to the external erosion of moving water. These "hills of uptilting," then, were hills not in consequence but in spite of denudation, and would have been many times loftier had it not been for the erosive action. Mr. Jukes then entered into a discussion as to the relations between the action of internal force and that of external erosive action, and declared his belief that all the striking external features were the result of the direct action of the external forces called the "weather," and were not caused by any direct action of the internal forces, which could only reach the surface through the thickness of the crust. He then examined these forces of erosion, and while he attributed to marine action all the greater and more general features, the great plains, the long escarpments, and the general outline of the mountains, he believed that the valleys which traversed the plains, the gullies that furrowed the sides of the hills, and the glens and ravines on the flanks of the mountains, were all due to the action of the ice or water which fell on them from the atmosphere. He did not give these views as altogether original, but mentioned M. Charpentier and Mr. Dana as having long ago applied them to the Pyrenees and to the Blue Mountains of New South Wales; but, having been long skeptical as to their reality, he now wished to record his conviction of their truth. Mr. Prestwich, Prof. Ramsay, and himself, while pursuing different lines of investigation, had all been simultaneously compelled to appeal to subaërial action as the only method of explaining the phenomena they had met with, and Dr. Tyndall had since fallen into the same line of march.

NEW OBSERVATIONS ON GLACIERS.

Prof. Tyndall has communicated to the London *Times* the following interesting statement: —

Many years ago, Mr. William Hopkins pointed to the state of the rocks over which glaciers had passed as conclusive evidence that these vast masses of ice move bodily along their beds. Those rocks are known to have their angles rasped off, and to be fluted and scarred by the ice which has passed over them. Such appearances, indeed, constitute the entire evidence of the former existence of glaciers in this and other countries, discussed in the writings of Charpentier, Agassiz, Buckland, Darwin, and other eminent men.

I have now to offer a proof of the sliding of the ice exactly complementary to the above. Suppose a glacier to be a plastic mass, which did not slide, and suppose such a glacier to be turned upside down, so as to expose its under surface; that surface would bear the impression of its bed, exactly as melted wax bears the impression of a seal. The protuberant rocks would make hollows of their own shape in the ice, and the depressions of the bed would be matched by protuberances of their own shape on the under surface of the glacier. But suppose the mass to slide over its bed, these exact impressions would no longer exist; the protuberances of the bed would then form longitudinal furrows, while the depressions of the bed would produce longitudinal ridges. From the former state of things we might infer that the bottom of the glacier is stationary, while from the latter we should certainly infer that the whole mass slides over its bed.

In descending from the summit of the Weigshorn, in August last, I found, near the flanks of one of its glaciers, a portion of the ice completely roofing a hollow, over which it had been urged without being squeezed into it. A considerable area of the under surface of the glacier was thus exposed, and the ice of that surface was more finely fluted than ever I have observed rocks to be. Had the tool of a cabinetmaker passed over it, nothing more regular and beautiful could have been executed. Furrows and ridges ran side by side in the direction of the motion, and the deeper and larger ones were chased by finer lines, produced by the smaller and sharper asperities of the bed. The ice was perfectly unweathered, and the white dust of the rocks over which it had slidden, and which it had abraded in its passage, still clung to it. The fact of sliding has been hitherto inferred from the action of the glacier upon the rocks; the above observation leads to the same inference from the action of the rocks upon the glacier. As stated at the outset, it is the complementary proof that the glacier moves bodily over its bed.

THE ARTESIAN WELL AT PASSY, FRANCE.

At a recent meeting of the French Academy, M. Dumas read a paper on the history and difficulties of the above-named work. The idea of boring this well originated with the necessity of obtaining an additional water supply for the city of Paris. This city rests upon a stratum of chalk about 500 metres in depth, covered with about fifty metres of various strata of tertiary soil, and itself resting on nearly fifty metres of marl or clay, which is in contact with the green-sands from which the celebrated well of Grenelle derives its supply. The successful boring of the latter had established the fact that the water which these sands received from localities at a distance from Paris might be made to rise to the surface, and even to thirty or forty metres above. But the experiment had only been tried for bores not exceeding a diameter of from twenty to thirty centimetres, yielding a supply of from 2,000 to 4,000 cubic metres of water per day. An engineer, however, M. Kind, came forward with an offer to bore a well of a diameter of sixty centimetres, yielding 13,300 cubic metres at an altitude of twenty-five metres above the highest point of the Bois de Boulogne. Though limiting his promises to the yield above stated, he declared his conviction that it would reach 39,600 metres; an assertion which most engineers considered exaggerated, deeming it highly improbable that an increase in the diameter would increase the supply.

On the twenty-third of December, 1854, the works were resolved on, and the spot chosen in the neighborhood of the Bois de Boulogne, where the high temperature of the expected column of water might be turned to account. But the enterprise was fraught with difficulties which it required the unflinching perseverance of M. Kind to overcome; although out of the 587½ metres which constitute the depth of the new well there were scarcely thirty offering any serious obstacle, and these were situated in the clay either above or below the chalk stratum.

On March thirty-first, 1857, the bore had already reached 528 metres, and water was hourly expected, when suddenly the tube of sheet iron which supported the clay was crushed in by its pressure at a depth of only thirty metres from the top. This accident it took nearly three years to repair. A shaft of the depth of fifty-three and a half metres had to be dug close to the bore, through all the most dangerous strata, and lined partly with sheet and partly with cast iron and masonry. Its diameter was three metres throughout the two-thirds of its depth, and 1.70 for the rest. It was a work of extreme difficulty. Cast-iron tubes, of the thickness of thirty-five millimetres (four-fifths of an inch), were starred or cracked in all directions, as if they were mere glass. More than once the workmen refused to risk their lives in this work, and the city engineers had to set the example of personal courage.

This stupendous labor was not brought to an end before the thirteenth of December, 1859. The old orifice was then cleared, and the boring recommenced, and continued without any further accident to the depth of 550 metres, when the tube, composed of wood strongly hooped with iron, and ending in a bronze pipe, two metres of which were fitted into the wood, the remaining twelve metres being free, stuck fast in such a way as to render all further progress nearly hopeless. However, M. Elie de Beaumont having, upon mature examination of the specimens brought up by the borer, declared water to be close at hand, it was resolved that the bore should be continued with a small diameter, to be afterwards enlarged, if necessary. Water was found, for the first time, at 577½ metres, but, as we know, remained a few metres below the level of the orifice. A second tube of sheet iron, seventy centimetres in diameter, two in thickness, and fifty-two metres in length, twelve of which were loopholed in order to let the water pass, was sunk, and soon stopped in the clay. The boring was now resumed, to attain the largest diameter, until the twenty-fourth of September, 1861, when M. Kind saw not only his promise fulfilled, but even his hopes to a certain extent realized. The bronze tube has remained where it was, but the concentric one of sheet iron has sunk to 380 metres. The yield of water from this well is 20,000 cubic metres in twenty-four hours — sufficient for the wants of 500,000 inhabitants. At the same time the produce of the well at Grenelle has diminished one-fourth.

At the same meeting of the Academy, M. Gaudin presented a communication in which he replies to the question, often asked, whether the supply of the artesian wells, bored in the neighborhood of Paris, can ever be exhausted. The stratum of green sandstone interposed between the strata of chalk and Jurassic limestone is of the average thickness of fifty metres; consequently, taking the depth of 577 metres of the artesian well at Passy as a criterion, there remains a depth of twenty-five metres of sand. A cubic metre of sand, closely rammed, weighs 1,600 kilogrammes, while compact quartz weighs 2,500 kilogrammes; hence, the stratum of sand, even supposing it to be closely packed, has interstices amounting to one-third of its bulk in the aggregate, so that every cubic metre of sand under water contains 333 litres of water. Now, the layer of sand existing under the chalk may be represented by a disc of 160 kilometres' radius, its surface amounting to 80,000 square millimetres, and its thickness to eight metres. The cubic contents of this disc are, therefore, 640,000,000,000 metres, which, divided by 10,000,000, then by 365, gives the quotient 175, being the number of years requisite to exhaust the supply of water at the rate of 10,000,000 cubic metres per day! This would be correct, supposing the quantity of water to remain stationary, and never to receive any increment by the infiltration of rain-water and that of rivers. This M. Gaudin calculates at half a metre per annum, and thence arrives at the conclusion that the annual increase of the water is double the quantity expended; so that the artesian wells in or about Paris are and must ever be inexhaustible.

Artesian Wells in the Desert of Sahara. — The Paris *Cosmos* states that in five years, terminating with 1859–60, fifty wells have been sunk in the Algerine Sahara, capable of yielding 36,761 litres of water per minute. 30,000 palms and 1,000 fruit trees have been planted. Numerous oases have been recovered from ruin, and two fresh villages established. The expense has not yet reached 298,000 francs, and has been covered by a slight additional tax, and by voluntary contributions from the Arabs. The water is slightly saline, and a little bitter, from the presence of Epsom salts, but is not found to be unwholesome.

THE FROZEN WELL OF BRANDON, VERMONT.

In 1859, the Boston Society of Natural History appointed a committee to investigate the phenomena of the so-called frozen well of Brandon, Vt., described in the *Annual of Scientific Discovery* for 1860. During the past year, this committee, consisting of John H. Blake, Esq., Dr. C. T. Jackson, and Prof. W. B. Rogers, have made a report, the substance of which is as follows: —

The frozen well of Brandon is situated about half a mile west of Brandon Hotel, on the estate of Mr. Abraham Twombley. It was in the month of November, 1858, and stoned up with boulders of limestone rock soon after. In excavating this well, the first strata were found to be sandy loam, then came coarse gravel, and a bed of rounded boulders, of sizes varying from a walnut to a foot or more in diameter, the spaces between the boulders being filled with fine, clayey sand. Twenty feet from the surface the boulder bed and soil were found to be frozen, and lumps of frozen earth, with pieces of ice, were raised, some of the lumps of ice being the size of a hen's egg. Frozen masses of the earth and lumps of the ice were taken away and exhibited in the village of Brandon. All the lower portion of the boulder bed was frozen; but on passing through it to the sand below, liquid water was found, which flowed up into the bottom of the well. The whole thickness of the frozen bed was estimated at from twelve to fifteen feet.

Before making an examination of the well the committee explored the geology of the immediate environs. The gravel bed was found to outcrop 250 feet north-west of the well, in a road-side cut. The rocky basis on which the drift material in which the well is sunk reposes on limestone. A section of the road-side cliff showed the so-called gravel bed, made up of erratic boulders, to be six feet in thickness; over this is a bed of gravel proper, one foot thick; then a layer of sand two feet thick, over which is a layer of ordinary sandy soil, mixed with mould. From the top of the strata it is evident that the gravel bed passes through the bottom of the well; and from other wells on both sides it was clear that this gravel bed does not go through, and that it is quite a narrow belt.

The well itself was found to be thirty-four feet deep, with two feet of water in it, while around the bottom of the stone-walling of the well was a thick rim of solid ice, a hole large enough for a bucket only remaining open, as it had been cut the previous winter. (This was in June, 1859.) The well is three feet in diameter.

The temperature of the water in the well was $32\frac{9}{10}°$ Fahrenheit. The temperature of the air in the well near its bottom was $35\frac{6}{10}°$ Fahrenheit. That of the air on the surface was $49\frac{1}{10}°$ Fah. The temperature of a spring just outside of the gravel bed was $51\frac{8}{10}°$ Fah. A well belonging to Mr. Strong, a few hundred yards east of Twombley's, was found to be fifteen feet deep, and the temperature of the water was $46\frac{4}{10}°$ Fah. A spring south-west of the frozen well, and not far distant, had a temperature of 9° Centigrade, or $48\frac{2}{10}°$ Fah. None of the other wells in the town freeze in the winter, or are remarkably cold. It is evident, therefore, that the geological formation around the frozen well determines its freezing character, and that the gravel bed, in some way, causes the water in that well to freeze, and to continue frozen through the summer months.

A pit was then sunk in the garden, 70 feet south-east of the frozen well, to the depth of twenty-nine feet. The strata were found to be clay and sand near the surface, and the lower part consisted of gravel and boulders. No frozen strata were found. After examining the results of this digging, another excavation was made to the west of the well, which gave more satisfactory results; for the moment the gravel and boulder bed were struck, they were found to be very cold, and near the bottom of the bed frozen earth was found. This was in the month of October, 1860, when the summer heat had penetrated as far as possible into the earth. This time was chosen expressly for the purpose of ascertaining whether the surface heat ever reached the bottom of this frozen bed. In the summer of 1859, the committee visited the well often, and drew ice from it in the months of June, July, and August; on one day when the temperature outside of the well was 93° Fah. in the shade.

On the seventeenth of September, 1861, another shaft was sunk, seventy feet from the cold well in a north-west direction, to the depth of thirty-four feet. The material passed through was gravel mixed with boulders. On the nineteenth of October, at a depth of twenty-six feet no ice had been found. The average temperature of the atmosphere was 47° Fah., and of the bottom of the shaft 46° Fah. On the twentieth the workmen reached a depth of twenty-nine feet, and found a stratum of frozen gravel about two inches thick. On the twenty-first they sunk to the depth of thirty-one feet, and found a stratum of frozen ground about eight inches thick, below which no frost was found that day. The day following, at a depth of thirty-three feet, the gravel was frozen so solid that it was difficult to break with a pick. The workmen supposed this to be only a crust or thin stratum of frozen ground, such as they had before encountered; but it continued solid all day, during which they only sunk one foot. Clear ice, in streaks, pervaded the gravelly mass. The external temperature at this time ranged from 47° Fah. to 57° Fah. The lowest depth reached, in this shaft, was, as before stated, thirty-four feet; and the men before leaving tried to drive an iron bar through the frozen ground at the bottom, but without success, the earth being too solid.

In concluding the report of their investigations, the committee say: Although we do not feel that we have been able to remove all doubts as to the true theory of the phenomena of the frozen well, still we incline to believe that the freezing is due to the nature of the conducting medium in which the well exists, and that the wave of heat in the summer months is not adequate to overcome the cold of the longer cold months, while the uncommonly severe winters of 1856 and 1857 may have lowered the temperature of the rocky masses of boulders, so that the wave of summer heat has not yet been able to reach the frozen mass, which, once congealed, would resist thawing on account of the slow conduction of ice. It should also be remembered that water does not conduct heat downward readily, though it does upward by convection.[1]

The existence of beds of boulders in other cold and frozen wells, as in one at Tioga, N. Y., seems to point to the same solution.

The ice in the Brandon well forms some time in November, and it remains until September, thus showing only a brief period when the temperature of the bottom of the well is above the freezing temperature, while the great mass of boulders remains much below it; the well, being more exposed, receives the first warmth by conduction of its walls exposed to the air.

Among the hypotheses which have been offered to account for the phenomena of the frozen wells, are the following: —

1. The penetration of cold currents of air through the boulder stratum. This hypothesis is without any foundation, because there are no open spaces, and the boulders are closely cemented together by being imbedded in clay and sand; and also because the fact is ascertained that there are no currents of air moving in the mass, or in the well, the flame of a candle placed near the stony walls not being in the least deflected.

2. The descent of cold air into the well, in mid-winter, communicating the degree of cold to the walls of the well. This conjecture is insufficient, since the ice existed before the well was sunk, and when there was no opening for the air to descend into. This fact was not only ascertained at the time the well was sunk, as witnessed by credible persons residing in the vicinity, but has also been fully verified by sinking a shaft into the boulder bed by this committee, and by the discovery of an extensive frozen stratum in October.

3. Radiations from the bottom of the well. If this conjecture was

[1] The familiar experiment of boiling water upon the surface of a cake of ice without melting it, and that of boiling water at its surface, by means of a plate of hot iron placed over it, while the water below is not heated, illustrates this statement.

It is true that the maximum density of water is at 39° Fah., and that it sinks when at this temperature in water that is either warmer or colder, but this movement is limited to a few degrees of temperature. Ice, having its particles fixed, does not allow of the varying of heat by convection, as it is called, and is a very bad conductor of heat, as is obvious to all who observe a cake of it exposed to a warm atmosphere.

well founded, other wells in the vicinity, many of which are more favorably situated for such radiation, should also be frozen; and yet such is not the case, and they never do freeze in the coldest winters.

4. It has also been imagined that some natural freezing mixture exists in the frozen strata, or in the water of the well. This is not the case, — the water being exactly like that of other wells in the neighborhood, and the boulder bed containing nothing but rocks, clay and sand.

5. That this boulder bed is the moraine of an ancient glacier, the ice and cold of which still remain. We doubt not that the boulders were rounded and accumulated by the action of moving ice; but it would appear improbable that ice should remain for many thousands of years, when liquid water exists both above and below this mass of drift, and percolation of warmer water is constantly taking place from the surface, and it is also introduced from below quite freely.

6. The well having been stoned up in the latter part of November, it has been supposed that the stones were very cold when placed in the well, and that they have retained their low temperature ever since, and thus, by conducting the heat away from the water in the well, they have caused it to freeze. On this hypothesis one observer predicted that "our curiosity would soon disappear," as the equilibrium of temperature would soon be restored between the water and the walls of the well. This hypothesis has required the committee to leave the question to be solved by time, and three years have passed, with the regular recurrence of the icy belt, and its equally regular disappearance in the autumn. Now, if it was the original coldness of the stones in the well that caused the ice to form, when those stones were once warmed above the freezing point they ought never again to fall below it, and cause the congelation of the water.

Since it appears that the nature and situation of the strata of earth, gravel and boulders around the well causes the low temperature of the winter months to be preserved in the well through the summer, it is probable that by imitating this condition of things in the construction of a well in a similar region, we could make a well that would freeze in the winter, and retain its frozen condition through the summer. The experiment might require two or three years for its fair trial, in order to afford time for the translation of the waves of heat. The committee also remark that the occurrence of ice in mines and caves where snow drifts abundantly into them is not similar to the case of the Brandon well, and requires a different explanation.

INTERESTING ILLUSTRATION OF GEOLOGICAL PHENOMENA.

A recent natural occurrence in California is worthy of preservation and notice, for the reason that it illustrates in a clear and decided manner certain phenomena of ancient deltas and estuary deposits of Oolitic, Triassic and Carboniferous ages, whose mixture of marine, fresh-water and terrestrial organisms are a puzzle to geologists.

In December, 1861, California was visited with a rain full of unusual violence and continuance, which affected the snows upon the Sierra Nevadas. The consequence was, that the mountains poured down rivers upon rivers of water, until the whole of that great basin of California which the mountains bound was entirely submerged. The only outlet to this water is the Golden Gate, the entrance to the bay at San Francisco from the Pacific Ocean. "Take the map of California," says a letter-writer, describing this flood, "and see where, on the south, the mountains come to a point below Tularo Lake, and then go up north to where they again join at Shasta, and then picture the whole of the immense tract of land they enclose under water, and the Bay of San Francisco, a vast river, pouring its volumes into the Pacific Ocean by the before-named Golden Gate. Fancy, also, the tides of that ocean having no effect in the bay, and welling up at its entrance, and you will have a feeble idea of the magnitude of the volume of water that for two months ravaged California.

"It was very strange to see the sea for about ten miles around the mouth of the bay. In the interior, about sixty miles from San Francisco, and at the *embouchure* of the northern rivers, are vast tracts of land covered with rushes and semi-aquatic plants, that go by the name of *tulé* lands, something like the paddy fields of India. Well, as the waters rose, these immense morasses rose also, and in process of time, becoming detached, floated away with the current in masses of from one hundred yards to half a mile in size, and they all floated out to sea, travelling, some of them, more than one hundred miles before their arriving. Once arrived in their grander sphere of action, it was the most extraordinary thing to see the myriads of water snakes, faithful to their home, twisting and twirling in the salt sea, and to see the water-fowl that screamed over their nests as though warning the islands of their danger, and to see our coast when any of the islands were thrown upon it, and the thousands and thousands of snakes wriggling their way over the shrubless sands that bound it for miles in search of anything to hide them from the wholesale slaughter that sticks and stones, and knives, and even guns, made among their host. All the salt-water fish left the bay, and all the oysters, like good men, died in their beds."

THE PLASTICITY AND ODOR OF CLAY.

In a recent paper on the above subject, read to the Geological Society (London), the author, Mr. C. Tomlinson, called attention to the circumstance that clay is only plastic up to a certain temperature; when heated beyond that point (which the author believes from experiments performed by him to be somewhere between six and seven hundred degrees Fahrenheit), it loses its plasticity and acquires the property of rigidity. Moreover, having once lost its plasticity, this quality can never be restored to it by any methods yet known to science. Further, this property cannot be produced artificially; the constituent elements of pure clay may be combined in the proportions indicated by analysis, but the clay thus produced is not plastic. It is commonly stated that it is the alumina which confers upon clay its plastic property, but the author showed that pure alumina, whether gelatinous, or after having been dried and ground up with water, never gives a plastic paste; nor can water be the cause, since melted glass and sealing-wax both possess the property.

The author considered that the phenomenon may be due to a change in the molecular arrangement of the particles of the clay and the consequent variation of the attractive force which holds them together, the particles under the circumstances under which clay is plastic being nearer to one another, and the attractive force consequently greater, than under the circumstances when the clay has the property of rigidity.

As to the odor of clay, the author pointed out some difficulties in the way of the common opinion that alumina is the cause of this property, and suggested various considerations which might lead to the elucidation of the point.

QUICKSILVER MINES OF CALIFORNIA.

The *San Francisco Mining and Scientific Press* says:—"There have been many recent discoveries of rich cinnabar in various portions of our prolific State, in consequence of the long stoppage of the great New Almaden Mine, owing to tedious and vexatious litigation. This mine, however, is at last in full operation again, and its annual product of over 1,000,000 pounds of quicksilver will again be in the market. The New Almaden, New Idria, Enriquita, and Gaudaloupe Mines of Santa Clara county, with the many recently-discovered and only partially-worked cinnabar veins of Napa and Sonamo counties (which contain liquid quicksilver), already turn out some 4,000,000 pounds of quicksilver per annum,—an amount nearly large enough to supply the world,—and, doubtless, when these latter shall have been more thoroughly opened, the yield will reach the high figure of 8,000,000 pounds, the value of which, at the rate of 30 cents per pound, would be no less than $2,400,000; and this we think is a moderate estimate. Hittell sets the average aggregate annual yield of the four great Santa Clara mines at 3,510,000 pounds, but it has reached as high as 4,275,000 pounds; and as they are by no means worked to the best advantage, we may safely look for largely increased returns as the operations of the companies are extended. Accounts recently received from Washoe also speak of rich cinnabar veins discovered. With so many mines and such vast yields, we may safely predict that the wholesale price of quicksilver will constantly decrease until it reaches eight or ten cents per pound. Quicksilver will then be used with a more liberal hand in the search for gold and silver, and many other advantages to the world will arise from its cheapness.

ECONOMIC EFFECTS OF THE RECENT GOLD DISCOVERIES.

An interesting paper on the above subject was presented to the British Association at its last meeting, 1862, by Mr. Henry Fawcett. He commenced by alluding to the confident predictions which were made when the rich gold deposits of Australia and California first became known, that the value of this metal would be rapidly and largely depreciated. Governments were advised to change the standard of value from gold to silver, and fundholders and others who were in receipt of a fixed money income were greatly alarmed at the prospect of a general rise in prices. All were ready to admit that these confident predictions have not been realized, for the depreciation in the value of gold cannot as yet have been very marked, since the highest financial authorities still dispute whether the new supplies of gold have produced even a small alteration in its value. Mr. Fawcett then stated that in the year 1848 the aggregate value of the gold existing throughout the world was £560,000,000, and so great had been the yield of gold from Australia and California that, if this present yield continued, these two countries would, in thirty-five years, produce gold equal in value to the entire quantity which previously existed. Previous to 1848 the entire annual production of gold did not exceed £6,000,000; the amount yielded by Australia and California had been in many years four times as great as this, and therefore it was very naturally supposed that gold must be depreciated in value. A large portion of these new supplies of gold were sent to England; and here it was necessary to employ it in one of the three following ways: — 1. In arts or manufactures. 2. In increasing gold currency. 3. In reëxporting the gold to foreign countries. The amount of gold employed in arts or manufactures is so small that this source of absorption may be neglected in comparison with the remaining two. It was stated that the gold coinage of Great Britain was increased from 1848–56 by £20,000,000. Mr. Fawcett then proceeded to explain with great care the connection between general prices and the quantity of money in circulation, and he affirmed that, if the population and wealth of a country increased, the value of gold must rise, or, in other words, general prices must decline, unless an increased amount of money is brought into circulation. A great portion of the buying and selling of the country is, however, carried on by checks, bills of exchange, and various other instruments of credit, which serve as substitutes for money. The extended use of these substitutes for money of course supplies the place of a metallic currency, and therefore it is almost impossible to arrive at a conclusion whether or not the £20,000,000 added to the British gold coinage in 1856 was sufficient to preserve a uniformity in the value of gold, while the population and wealth of the country was increasing so rapidly as it did during those years. In the first place, the amount of this increase of wealth cannot be ascertained; and, secondly, some of the substitutes for money may be more largely used. For instance, many trading transactions, in which money was formerly used, are now carried on by checks. Mr. Fawcett next inquired whether a comparison of general prices now with what they were previous to 1848 would more accurately ascertain than the method just alluded to whether or not the value of gold has been depreciated. When this comparison was made, they were at once perplexed by observing that the price of many commodities had declined, whereas the price of others had risen. But these changes in price could be accounted for independently of any change in the value of gold. For instance, many manufactured articles had become cheaper because improved methods of production had been introduced, and, on the other hand, meat and dairy produce had become dearer in consequence of the increased demand of a larger population. It was, therefore, proved that the depreciation in the value of gold could not as yet have been very marked, since it was not evidenced by a decided effect on general prices. From this negative result a most important conclusion could, however, be deduced, for it was evident if the large supplies of gold had not depreciated the value of this metal, that then its value must have been greatly and rapidly augmented if these supplies had not been forthcoming. The great increase in British trade and commerce since 1849 showed how largely the wealth of the country had been augmented, and if, therefore, more gold had not been forthcoming, a great and sudden rise must inevitably have occurred. The consequences of this must have been most disastrous, for the terms of every money-contract would be changed. Mr. Fawcett then said the East had really absorbed the greater portion of the additional gold which had been produced. British exports both from India and China had enormously increased; large amounts of capital had been sent from Great Britain to India for the purpose of carrying out public works, but British imports from those countries, especially China, showed no corresponding increase. The consequence of this was that the balance of trade was so largely against Great Britain that an amount of specie varying from £10,000,000 to £14,000,000 had for some years been annually exported to the East. The principal portion of this specie had been silver, and the silver had been to a great extent supplied from the currencies of France and other countries. Gold had taken the place of this silver, and therefore the East had caused a large portion of the additional gold to be absorbed. No one could confidently predict how long Eastern trade might continue as it is now. The Chinese might some day prefer to import manufactured goods instead of being paid by us in specie. If such a change occurred, the export of specie to the East would cease, and then, no doubt, such an amount of gold as we had been obtaining from California and Australia could not be absorbed in Europe without a depreciation in its value. Mr. Fawcett, therefore, concluded that, although the balance of evidence was, on the whole, in favor of the opinion that the value of gold would not for a long time be depreciated, yet such a depreciation might very possibly occur, and therefore prudence would dictate that it should, as far as possible, be considered in making any permanent arrangements which involve fixed money payments.

THE SALT SPRINGS OF MICHIGAN.

On the 20th of June, 1797, the first leases were granted for the manufacture of salt at the Onondaga Springs, in New York, and since that time, and to the close of the year 1860, 130,737,157 bushels had been produced. Within a few years past a new and powerful rival to this, as it were, monopoly of production, has been created by the discovery of the existence of extensive saliferous rocks in Michigan, a discovery mainly due to the labors of Prof. Winchel, the State Geologist. In regard to the origin and position of these deposits, Prof. W., in a recent communication to *Silliman's Journal*, says:—

"The perfectly dish-shaped conformation of the strata of the lower peninsula of Michigan has prevented the escape to the sea of such soluble substances as were originally embraced in the marine deposits from which the rocks were formed. Were there any point in the margin of one of these rocky basins lower than its central portions, chance for escape of all its soluble contents would have existed; and it is doubtful whether in such case brines could have been retained to the present day, in any considerable quantity. Our subterranean peninsula basins are comparable with the superficial basins in which the salt lakes of the world are located. Neither class of basins has an outlet. The basin of Lake Superior was once filled with water as salt as that of the Great Salt Lake. Both have received accessions of fresh water; but while one has been drained by an efflux which has continually carried away some portions of the chloride of sodium, the other has been drained only by evaporation. The salineness of one has been reduced almost to an infinitesimal quantity; that of the other is unimpaired, if it has not actually been strengthened by the loss of more water than it has received."

The subterranean salt-basins of Michigan are three in number, and, unless all geological indications are fallacious, they contain the most abundant and accessible salt deposits upon the North American continent, east of the Mississippi. The principal basin extends from Grand Rapids, in Kent County, to Sanilac County, and to an unknown distance toward the north. "Within this distance," says the State Geologist, "the area covered by the coal measures may be taken as the area underlain by the saliferous strata of maximum productiveness." These strata are made up of a remarkable series of salt-bearing shales, with intercalated beds of gypsum and limestone, and with a maximum thickness, according to the authority above quoted, of 184 feet. The principal salt wells of Michigan are now located in the Saginaw Valley, and their present annual product is upwards of 2,000,000 bushels per annum; a growth in two years equal to that attained to by the Onondaga Saltworks of New York in 1834, thirty-eight years after the salt springs had passed under the superintendence of the State. Such, moreover, is the strength and abundance of the brine furnished by the Saginaw wells, and the cheapness of fuel, that a barrel of salt can be made for sixty-four cents; while the cost of the same at Syracuse, New York, is at least ninety-five cents.

The annual consumption of salt in the United States for the year 1859 was estimated at fifty-two and one-half pounds *per capita*, or in the aggregate about 30,692,000 bushels. Of this amount not quite fifty per cent. is of domestic manufacture, — the balance being an imported article. In 1858 the amount of salt received in the city of Chicago was 333,988 barrels, a fact which at once indicates the importance of the salt trade of the United States at the West.

GEOLOGICAL SUMMARY.

Sulphur from Sicily. — The exportation of sulphur from Sicily, during 1860, amounted in the aggregate to 1,794,593 cwts., of which 648,141 cwts. went to England, 525,976 to France, 96,462 to Holland and Belgium, 154,436 to Naples, 3,620 to the rest of Italy, 58,385 to Greece, 196,694 to America, 110,879 unknown destination.

Production of Copper. — The *Lake Superior Mining Journal* gives the following information respecting the production of copper: —

"In 1830, the total productions of the copper mines of the world was about 25,500 tons of metal, and of this amount Great Britain produced 13,200, or more than fifty per cent. of the whole, while the United States and Canada furnished but fifty tons, or two-tenths of one per cent. The Russian Empire then produced nearly 4,000 tons; the Austrian Empire 2,150 tons; the whole of Asia some 2,500 tons. In 1853, twenty-three years later, Britain had only increased her annual product to 14,500 tons, her percentage of the whole amount receding to twenty-six; while Chili, in South America, which in 1830 only yielded 200 tons, had raised her product to 14,000 tons, or over twenty-five per cent. of the total production. From that period forward to the present time, the copper production of the Chilian mines, we believe, exceeded those of any other country; the value of their exports in that metal alone amounting to $10,760,000 in 1857, while the value of British mine products for the same year was worth about $9,500,000. The Russians had increased the yield of their mines to 6,500, or eleven and three-fourths per cent. of the whole; the Austrians 3,300 tons, or six per cent.; the whole of Asia only 3,000 tons, or five and one-half per cent.; while the United States and Canadas raised that year 2,000 tons, or over three and one-half per cent. of the total products for that year, which were about 55,700 tons; Australia and New Zealand produced about 3,000 tons; Cuba, 350 tons; Scandinavia, 2,000 tons; the German States, 1,450 tons; and the rest of Europe, exclusive of the countries above named, 1,000 tons. During the past ten years the mines of Lake Superior have probably increased their production more rapidly than those of any other country, the exports for 1861 — 7,500 tons of metal — being about twelve times greater than those of 1851."

Texture of Copper. — M. Vivian, of France, some time ago showed that manufactured copper always has a porous and cellular texture, whilst native copper is always crystalline. Now he proves that the native copper from Lake Superior is neither crystalline nor cellular, but dense, ductile, and fibrous, as though it had been violently compressed when cold. When melted it however takes the structure of all manufactured copper. — *Cosmos.*

Immense Mass of Copper. — During the past year another immense mass of metallic copper has been discovered in the Lake Superior district, in the vicinity of the so-called Mesnard Mine. Little of the mass was above the surface when discovered, and that little was so covered by moss and small underbrush as to hardly attract attention. Upon being uncovered, and the soil removed from around its sides, traces of Indian workings were found,— pieces of charcoal, and half a dozen stone hammers, were taken out; and the eastern end of the mass shows plainly that a portion has been broken off. The average dimensions, says the *Lake Superior Mining Journal*, are, — length, fifteen feet seven inches; width, three feet seven inches (it is full five feet in one place); thickness, one foot six inches; giving 87,135 cubic feet. All these measurements are rather under than over the average, and give a weight to the mass of nearly twenty-seven tons.

The immense weight of this boulder of copper naturally suggesting that its source or vein was not far distant, search was made, and resulted in the discovery, about forty feet distant, of a vein of metallic copper of huge dimensions. At last accounts, this new wonder had been stripped some five feet in breadth for a length of twelve feet, and three thick, with no indication of growing less at any point.

Canadian Pleistocene Fossils and Climate. — Prof. Dawson, in a paper recently published in the *Canadian Naturalist*, gives a more complete list of the fossils of the drift in Maine, Canada, Labrador, etc., than has been before presented, and makes some interesting deductions from them in regard to the physical geography, climate, etc., of that part of the North American continent during that period.

From facts now given, and others before reported, the conclusion is unavoidable, that a far greater degree of cold prevailed during the Pleistocene epoch than at present. The causes of this difference of climate Prof. Dawson finds in great recorded changes of level, and in the different distribution of land and water; during the cold period — as he infers — the relative proportion of dry land surface in the arctic regions to that in the temperate zone having been considerably greater than now.

Fossil Fishes of North America. — Dr. Newberry, in a communication to *Silliman's Journal*, on the above subject, states that, up to the present time, we have no evidence that many of the most characteristic genera of fishes of the Devonian rocks of the Old World, such as the *Asterolepis*, *Coceosteus*, *Cephalaspis*, *Osteolepis*, *Acanthodes*, *Cherolepis*, etc., ever had any existence in America.

The evidence on this point is of course as yet only negative, and may all be soon reversed, but it is nevertheless rather remarkable that while most of the Devonian molluscous genera and many species are common to the two continents, the fishes, so far as known, are all specifically distinct, and the larger part of them generically different.

Land Animals in the Coal Measures of Nova Scotia.— Dr. Dawson, in a communication to the Journal of the Geological Society, London, states that he has recently obtained numerous additional animal remains from the cliffs of the South Joggins, Nova Scotia, among them some reptilian skeletons, one of which, the *Dendrerpeton acadianum*, he considers the most perfect carboniferous reptile hitherto discovered. These were obtained from a tree trunk fossilized *in situ*, and it also contained, amongst other treasures, many remains of insects, the most interesting being a compound eye, with the facets perfectly preserved.

Interesting Fossils. — The recent fall of a cliff near Hastings, England, has brought to light an interesting slab of stone, bearing on its surface the clear impression of the foot of a gigantic bird. It has three toes, each of which is about nine inches long in the tread, with a claw at the end, of perhaps two inches in length. The back of the foot, where the three toes meet as in a centre, does not appear; that part of the foot did not reach the ground. But still further back is the mark made by the point of the spur, or fourth toe. From the point of the middle claw to this mark of the spur it measures twenty-four inches, and in width twenty inches. The whole of the slab is covered with the lines of ripple made by the waves upon soft mud; and there are numerous other impressions, more or less perfect, of the same bird's claws on other slabs of stone. The bird which has left us this footprint may be supposed to have been at least twelve feet high, and perhaps much more. The strata in which these fossils occur are referred to the middle division of the Wealden formation.

Last Ape in Europe. — A recent English writer makes known the interesting fact that only four individuals of the Barbary ape *(Innus Sylvanus)* now exist on the rock of Gibraltar. He proposes, with the intention of obviating the extinction of this species in Europe, to introduce a number of apes from Apes Hill (Mount Abyla), on the Moorish side of the straits, and to preserve them rigorously under severe penalties to be enforced against those lovers of sport who may shoot them. This ape, perchance the last representative of a fauna which united the present animal populations of Africa and Europe during the later Pliocene age, has now reached the utmost limit to which a species can attain, and is succumbing to the same extinctive influences which are rapidly causing the extirpation of the lion on the slopes of the Greater and Lesser Atlas.

Discovery of Microscopic Organisms in Palæozoic Rocks. — Dr. M. C. White, in a communication to *Silliman's Journal*, shows that many of the hornstone nodules found in the Devonian and Silurian rocks of this country abound in organisms referable to the Desmidiæ and Diatomaceæ, with numerous spicula of sponges and fragments of the dental apparatus of Gasteropods. These observations are of great interest to the geologist as well as the microscopist as they carry back to a very early epoch forms of life which have hitherto been looked upon as belonging only to a much more recent era in the life of our planet. The extreme abundance of hornstone nodules in one palæozoic limestone will render it easy to multiply observations in the new field of research; and it should be remembered by those who undertake such examinations, that the use of turpentine renders the chips of chert almost as transparent as glass. — *Silliman's Journal.*

Different Ages of American Gold Deposits. — At a recent meeting of the Boston Natural History Society, Mr. Marcou stated that the gold of the Atlantic coast was of another formation from that of California. The slate of Nova Scotia was metamorphic Taconic rock. There had been found in North Carolina beds of red sandstone containing gold washed into it during its formation, showing its existence previous to the formation of the latter. In California the quartz gold-bearing veins seldom occur in the slate itself. We appear to have in America gold of two different periods. In Australia the gold is entirely of the drift period, while that of the Atlantic coast is of anterior date.

Gold of Australia. — At the International Exhibition, London, 1862, the total mass or bulk of the gold exported from Australia from 1851 to 1861 — ten years — was represented by a gilded truncated pyramid, ten feet square at the base, and forty-two feet high. These dimensions in solid gold were equivalent to 800 tons or 520,000,000 of dollars; which is the exact amount transmitted from Australia during the time above mentioned.

Coal Production of Pennsylvania. — The Philadelphia *Ledger* gives the production of coal in the State of Pennsylvania, for 1862, at 8,295,472 tons, of which 7,481,718 were anthracite.

Association of Granite with Tertiary Strata. — At a recent meeting of the London Geological Society, Mr. J. G. Hawkins stated the existence of a granitic formation in the Island of Jamaica, which pierces both rocks of the carboniferous series, and also well characterized tertiary strata; wherefore, Mr. H. has no doubt that the age of the granite is tertiary.

Volcanic Condition of Vesuvius. — At the meeting of the British Association, 1862, Dr. Daubeny stated that Vesuvius appears during the last few years to have entered upon a new phase of action. Its eruptions are more frequent but less violent than they were formerly; they proceed from a lower level than they did at an earlier period, and they give gaseous principles, such as the vapor of naphtha and light carburetted hydrogen, never before detected. The last eruption caused an elevation of the coast to the height of three feet seven inches above the level of the sea, which has not been observed on any preceding occasion. Dr. Daubeny suggested that Vesuvius was passing into the condition of a mud volcano, the products issuing from it being simply owing to the action of volcanic heat on the contiguous beds of Appenine limestone containing bituminous matters; hence the carbonic acid and carburetted hydrogen and naphtha vapor emitted, which were to be regarded as mere secondary products, to be distinguished from the muriatic and sulphurous vapors indicating primary volcanic action.

Influence of Water on Volcanic Action. — In a paper recently read before the French Academy, by M. Pissis, the author stated that it is generally believed, in those districts of South America which are most subject to earthquakes, that these disturbances occur during the rainy season, and up to the period of drought. During twelve years of his own residence on the spot this theory has held good, and the years of most violent rain were distinguished by a greater number of earthquakes; and he adds, that if we consider that during the wet season the Andes are covered with a dense bed of snow, which is perpetually melting from contact with the soil, it will be obvious that an extensive infiltration must take place; so, if there exist any fissures communicating with the interior, large quantities of water may be brought into contact with incandescent matter, and thus occasion very powerful disturbances.

Age of the Delta of the Mississippi. — Messrs. Abbot and Humphreys, in their elaborate work on the Physics and Hydraulics of the Mississippi, recently published by the United States Government, assign four thousand four hundred years as the approximate age of the Mississippi since it assumed its present condition of a delta-forming river, and state their reasons for believing that it existed before this as a clear stream. They consider that the original mouth of the Mississippi was near the present efflux of *Bayou Plaquemine*, and that, consequently, its advance into the Gulf has been about 220 miles. The present rate of advance of the mouth is about 262 feet per annum, which will not probably be exceeded hereafter.

The Ancient North American Continent. — Mr. E. Hull, of the Geological Survey of Great Britain, is of the opinion that the source of the sediments which compose the carboniferous rocks of Great Britain was in an ancient North Atlantic continent, for the existence of which Lyell, Godwin-Austen, and others, have argued; and he infers that the shores of this *Atlantis*, composed principally of granitoid or metamorphic rocks, were washed on the west side by a current running south-west, which drifted the sediment in that direction; and, on the other, by a current running south-east, which carried sediment over the then submerged British area.

Modern Elevation of Land in Scotland.—At a recent meeting of the London Geological Society, Mr. A. Geikie, of the British Geological Survey, presented evidence, recently obtained, which tends to show that a "portion of the coast of the Firth of Forth has been elevated not only within the human period, but even since the first years of the Roman occupation." After alluding to the position and nature of the raised beach which, at the height of from twenty to thirty feet above the present high-water mark, fringes the coast-line of Scotland, the author proceeded to describe the works of art which had been found in it. From their occurrence in beds of elevated silt and sand, containing layers of marine shells, it was evident that the change of level had been effected since the commencement of the human period. The character of the remains likewise proved that the elevation could not be assigned to so ancient a time as the Stone Period of the archæologist. The canoes which had from time to time been exhumed from the upraised deposits of the Clyde at Glasgow clearly showed that at the time when at least the more finished of them were in use, the natives of this part of Scotland were acquainted with the use of bronze, if not of iron. The remains found in the corresponding beds of the Forth estuary likewise indicated that there had been an upheaval long after the earlier races had settled in the country, and that the movement was subsequent to the employment of iron. From the Firth of Tay similar evidence was adduced to indicate an upheaval possibly as recent as the time of the Roman occupation. The author then cited several antiquaries who from a consideration of the present position of the Roman remains in Scotland had inferred a considerable change in the aspect of the coast-line since the earlier centuries of the Christian era. He pointed out also several circumstances in relation to these Roman relics which tended to show a change of level, and he referred to the discovery of Roman pottery in a point of the raised beach at Leith. The conclusion to which the evidence led him was that since the first century of our era the central parts of Scotland, from the Clyde to the Forth and the Tay, had risen to a height of from twenty to twenty-five feet above their present level.

A FEATHERED FOSSIL FROM THE LITHOGRAPHIC LIMESTONES OF SOLENHOFEN, GERMANY.

Notwithstanding the numerous imprints of feet, resembling those of birds, found in mesozoic strata, only two unchallenged discoveries of reputed bones of birds have been made in deposits older than the lowest tertiary. The first of these is the *Cimoliornis diomedeus*, a long-winged bird from the English chalk, described in 1840 by Prof. Owen, from a leg and wing-bone which he considered to have belonged to "one of the longipennate natatorial birds, equalling in size the albatross." The second recorded discovery of bird remains in mesozoic rocks is noticed in the supplement to the fifth edition of Lyell's "*Manual of Geology*," 1859, as having been made in 1858 in the Upper Greensand, near Cambridge, England. The bird in this instance was rather larger than the common pigeon, and probably belonged to the order *natatores*, and, like most of the gull tribe, had well-developed wings.

In deposits of the tertiary age, the remains of birds are not uncommon. The British Museum contains specimens from nine localities in French and English Eocene and Miocene deposits, and has also the remains of a large bird from the Sewalik Hills of India; casts of the bones and egg of the Æpyornis from Madagascar, and the entire skeleton of the Dinornis, and very numerous separate bones of this genus and Palapteryx from New Zealand. With the two exceptions of the Eocene slate rocks of Glaris, in which the almost entire skeleton of a small passerine bird, about the size of a lark, has been discovered, and the gypsum quarries of Montmartre, where two or three connected skeletons of different species of birds have been found, these remains consist of *detached bones or fragments only*, or of eggs (from Auvergne) or feather impressions (from Aix and Bonn). Indeed, the whole collection of *Ornitholites* known could be displayed in a single table-case of ordinary size.

This, of course, is *exclusive* of the great New Zealand and Madagascar wingless birds, the Dinornis and Æpyornis, the Notornis and Palapteryx, which, like the Dodo and Solitaire, have perhaps all been exterminated by the agency of man, or within the historic period. When we compare this dearth of evidence in the geological record with the vast numbers of species of living birds (very partially illustrated by the collection of stuffed examples in the Ornithological Gallery of the British Museum), we cannot but ask the question, — Why are no fossil birds found in strata in which remains of other animals frequently occur, which *at first sight* appear as little likely to have been preserved as the bones and feathers of a bird? Sir Charles Lyell remarks, that "the powers of flight possessed by most birds would insure them against perishing by numerous casualties to which quadrupeds are exposed during floods." And again, "If they chanced to be drowned, or to die when swimming on the water, it would scarcely ever happen that they would be submerged, so as to become preserved in sedimentary deposits."

That they can be readily preserved under favorable circumstances is proved by the fine examples found at Montmartre and Glaris.

Quite recently, however, there has been discovered in the well-known lithographic limestones of Solenhofen, near Munich, Germany, the remains of a most curious *feathered* animal, the exact nature of which geologists are not as yet fully agreed upon, but which Prof. Owen is inclined to regard as a bird. The age of the lithographic limestones of Solenhofen is supposed to be that of the Lias, the formation being of marine origin, and abounding in remains of cuttle-fishes, ammonites, crustacea, fishes, and also of winged insects and pterodactyls. From the immense demand for this stone for lithography, the quarries are as extensive as any in Europe. The quarrymen work upon the lines of stratification, which are beautifully parallel, and all the fossils are found upon the natural surfaces, presenting an impression and counterpart in almost every instance. The feathered enigma in question presents precisely similar appearances to all other included organic remains, being imbedded upon the surface of one layer, and impressed in intaglio into the one overlying it, which bears not only the cast, but portions of the bones upon its surface. The following is a description of the remains, as they now exist in the British Museum, for which it was purchased:—The skull, neck, and both hands are wanting, but all the dorsal vertebræ belonging to the tail are well preserved. The humerus and fore-arm, consisting of a radius and ulna, are present on both sides. The pelvis, more like that of a pterodactyl than a bird, is imperfect, the right side only remaining. The thigh-bone is showy but not long, and the shank not perceptibly divided into tibia and fibula. The tarsus consists of a single powerful bone shorter than the shank, and having its lower extremity widened, and bearing three articular processes to which as many toes are attached. The latter are of moderate length, and armed with strong hooked claws. These may have been used for clinging, like those of the pterodactyls and bats, or as offensive weapons, like the fighting spur with which the wings of the spur-winged goose of the Cape and Central Africa, and some others, are armed.

The "merrythought," or *furculum*, is seen lying between the wings. The ribs, small and unbird-like, are detached, and scattered on the surface, as if the head, neck, breast, and body had been torn off or eaten out by some other bird of prey or small carnivorous animal, wandering at low water upon the estuarine flats bordering that ancient oolitic sea.

Except to the comparative anatomists, these singular remains might present nothing striking, were not the anterior limbs and tail covered with feathers, which have left their impressions in well-marked lines. "From the short, broad bone which lies close to the extremity of each fore-arm there issues a radiating fan of feathers, by which two feathered wings are produced, having their external outline curved like a bow." The tail is also feathered, but the feathers are shorter than those of the wings. The hind limbs seem well adapted for hopping, running, or perching; and the wings (which evidently were adapted for flight) must also have received support in proportion to their size from the body of the animal.

The vertebræ of the tail are twenty in number, and are of a narrow, elongated form, the dimensions of which slowly but constantly diminish, so that the last is the smallest. The feathers of the tail are attached in pairs to each vertebra throughout its entire length. It is in the form and number of the caudal vertebræ, and the arrangements of the tail-feathers, that the great and striking peculiarity of this remarkable creature lies.

In all recent birds we find the tail very short and powerful, composed of vertebræ varying from five to nine in number, having spinous processes on their upper and under side, and the last vertebra very peculiarly formed, and, with few exceptions, *always the largest.* To this last joint all the tail-feathers in living birds are attached, and on it we find that peculiar oil-gland to which the bird applies its beak, and so anoints and renders waterproof every feather of its body.

Taking into consideration the remarkable divergence presented by the tail of this fossil creature from all known birds, and also the antiquity of the formation in which it occurs, we may at least safely infer that (if it be a bird at all) it represents perhaps one of the very earliest examples of its class. And this seems the more consistent when we consider the analogous change which has taken place in the class of fishes. For in the oldest fossil fish we find the same curious elongated tail (seen only in the sharks and sturgeon of the present day), in which the vertebral column is prolonged into the upper lobe of the caudal fin, forming the characteristic feature of the *Heterocercal* fishes. Whereas in the almost universally-prevailing type of modern fishes the tail-fin springs from *the last joint* of the vetebral column, giving us the order of *Homocercal*, or even-tailed fishes.

That the feathers are real *bona fide* feathers like those of a bird, seems to be placed beyond all doubt by the evidence of the impressions of both wings and tail, descending, as they do, to microscopic exactness. It has been suggested that a creature furnished with such feathers *must have had a beak* to keep them in order with.

Among the flying lizards of the Solenhofen slates is one described by H. Von Meyer, under the name of *Rhamphorhynchus*, as having "the *fore part* of each jaw *without teeth*, and probably incased in a *horny beak;* but behind this edentulous portion there are four or five large and long teeth, followed by several smaller ones. The tail *long, stiff, and slender*." Such a flying reptile *might have been endowed with feathers*, in which case the toothless portion, incased in a horny beak, would be well adapted for pluming and cleaning its wings and tail.

Such is the present state of the evidence. There is nothing in this fossil which elucidates the origin of the bird-tracks of Connecticut, although perhaps contemporaneous with them.

Professor Owen decidedly inclines to the opinion that this curious creature is a bird, but many very distinguished naturalists, who have carefully examined it, have professed themselves unable to come to any such positive conclusion.

PREHISTORIC MAN.

Since the attention of the scientific world has been attracted to the discoveries of M. Boucher de Perthes in the gravel-beds of Amiens and Abbeville, of France, facts connected with the early history of the human race have continued to turn up, and now show themselves in a very different light from that in which they were formerly wont to be viewed. An interesting discovery is noticed in a late number of the *Revue Archéologique*, made during the summer of 1861, near Laon, in France, in the department of the Aisne. In this locality a bed of lignite is worked for agricultural purposes. This bed lies at the foot of a small hill of the tertiary epoch, at the base of which occur argillaceous strata alternating with the lignite. Above are large masses of sand, including some layers of shells, and over them again come argillaceous beds, while the top of the hill is composed of hard *calcaire grossier*. The lignite bed is reached by subterraneous galleries, which run in different directions beneath the hill, some to a great distance. It is about two metres thirty centimetres in thickness, and is covered by a marly and sandy stratum full of fossil shells (*Cyrena cuneiformis*, *Ostræa bellovacina*, *etc.*) In August last the workmen discovered a small ball of chalk lying at the top of the lignite bed, and touching that which overlies it. This ball, about six centimetres (two inches) in diameter, attracted attention by its symmetrical shape, and, on being carefully examined, seemed to present evident marks of human workmanship. It seems impossible to arrive at any other conclusion than that it was formed and deposited in the place where it was found previous to the superposition of the fossil bed upon the lignite. This discovery, if substantiated, would carry back the existence of man to an early period in the formation of the great Paris tertiary basin. It is recorded that a flint axe was found forty years ago in the middle of a bed of the same lignite, worked near the village of Liez, canton de la Fère, in the department of the Aisne.

It will be remembered that a human skull, of a very curious and abnormal shape, was discovered, about two years since, in a cave in the province of Liége. (*See Annual Scien. Dis.* 1862, pp. 363–365.) M. Malaise, a Belgian palæontologist, exploring in the same province, has recently discovered certain fragments in a cave at Engihoul, which are valuable as evidence. The cave contains a bed of porous and pebbly silt, varying in thickness from two to three feet, under which lies a layer of stalagmite less than two inches thick; and it was while examining the soil beneath the stalagmite that the fragments in question were found. They consist of portions of two lower jawbones and three pieces of skull. In each jawbone the last three molars remain, all but two of which are much worn, and one is decayed. The pieces of skull are identified as fragments of the occipital and parietal bones; one of the latter is remarkably thick (eight millimetres). Pains were taken at the time of the discovery to observe that in their color, degree of decomposition and position, the human bones were in no way to be distinguished from the other animal remains which were confusedly accumulated under the stalagmite.

Additional evidence bearing upon the existence of man prior to the so-called drift period has recently been obtained by M. Lartet, a French geologist, in the south of France, on the head-waters of the Garonne.

Some ten years since, in Aurignac (Haute Garonne), in the *Arrondissement* of St. Gaudens, near the Pyrenees, a cavern was discovered in the nummulitic rock. It had been concealed by a heap of fragments of rock and vegetable soil, gradually detached and accumulated, probably by atmospheric agency. In it were found the human remains, it was estimated, of seventeen individuals, which were afterwards buried formally by the order of the mayor of Aurignac. Along with the bones were discovered the teeth of mammals, both carnivora and herbivora; also certain small perforated corals, such as were used by many ancient peoples as beads, and similar to those gathered in the deposits of Abbeville. The cave had apparently served as a place of sacrifice and of burial. In 1860, M. Lartet visited the spot. In the layer of loose earth at the bottom of the cave he found flint implements, worked portions of a reindeer's horn, mammal bones, and human bones in a remarkable state of preservation. In a lower layer of charcoal and ashes, indicating the presence of man and some ancient fireplace, or hearth, the bones of the animals were scratched and indented as though by implements employed to remove the flesh; almost every bone was broken, as if to extract the marrow, as is done by many modern tribes of savages. The same peculiarity is noticed in the bones discovered among the "water-huts" of the Danish lakes. In this deposit M. Lartet picked up many human implements, such as bone knives, flattened circular stones, supposed to have been used for sharpening flint knives, perforated sling-stones, many arrow-heads and spear-heads, flint knives, a bodkin made of a roebuck's horn, various implements of reindeer's horn, and teeth beads, from the teeth of the great fossil bear (*Ursus spelæus*). Remains were also found of nine different species of carnivora, such as the fossil bear, the hyena, cat, wolf, fox, and others; and of twelve of herbivora, such as the fossil elephant, the rhinoceros, the great stag (*Cervus elephas*), the European bison (*aurochs*), horse, and others. The most common were the aurochs, the reindeer and the fox. How savages, armed only with flint implements, could have captured these gigantic animals, is somewhat mysterious; but, as M. Lartet suggests, they may have snared many of them, or have overwhelmed single monsters with innumerable arrows and spears, as Livingstone describes the slaying of the elephant by the negroes at the present day.

With reference to the mode in which these remains were brought to this place, M. Lartet remarks: — "The fragmentary condition of the bones of certain animals, the mode in which they are broken, the marks of the teeth of the hyena on bones, necessarily broken in their recent condition, even the distribution of the bones and their significant consecration, lead to the conclusion that the presence of these animals and the deposit of all these remains are due solely to human agency. Neither the inclination of the ground, nor the surrounding hydrographical conditions, allow us to suppose that the remains could have been brought where they are found by natural causes."

The conclusion, then, in palæontology, which would be drawn from these facts, is, that man must have existed in Europe at the same time with the fossil elephant and rhinoceros, the gigantic hyena, the aurochs and the elk, and even the cave-bear. This latter animal is thought by many to have disappeared in the very opening of the Post-Pliocene period; so that this cave would, judging from the remains of that animal, have been *prior* to the long period of inundations in which the drift-deposits of Abbeville and Amiens were made. The drift which fills the valleys of the Pyrenees has not, it is evident, touched this elevated spot in Aurignac.

In chronology, all that is proved by these discoveries of M. Lartet is, that the fossil animals mentioned above and man were contemporaries on the earth. The age of each must be determined inferentially by comparing the age of strata in which these animals are usually found with the age in which the most ancient traces of man are discovered, such as the deposits already described in the north of France.

The Fossil Remains of Man. — The following is an abstract of a lecture recently delivered on the above subject before the Royal Institution, London, by Prof. Huxley: —

The purpose of the lecture was to give an explanation of the interest attaching to two casts upon the table,—the one that of a skull, discovered and described by Professor Schmerling, from the cave of Engis, in Belgium; the other, discovered by Dr. Fuhlortt, and described by Professor Schaffhausen, from a cave in Neanderthal, near Düsseldorf,—the former being the oldest skull whose age is geologically definable, the latter the most aberrant and degraded of human skulls.

The nature and extent of the cranial modifications exhibited by the man-like apes and by man were discussed; and their modifications were shown to depend upon variation in the capacity and in the form of the cranium, and in the greater or less development of its ridges, and in the size and form of the face. The *skull of a negro* was shown. Its breadth was small in proportion to its length,—in fact, was only six-tenths of it. The *skull of a Turk*, on the contrary, was in breadth nine-tenths of its length. All skulls come under one or other of these classes. Taking eight-tenths of the length as a standard from which to classify skulls according to the proportion between their length and breadth, all that have for breadth a less proportion than eight-tenths of the length are termed *dolichocephalic*, or long-headed; all that have a greater proportion, or even that proportion (eight-tenths) of the length in the breadth, are termed *brachycephalic*, or round-headed.

Skulls which are of the second class generally have the jaws *orthognathous*,—nearly or quite in a perpendicular line with the forehead. Those of the first class have the jaws *prognathous*, or more prominent than the forehead.

If a line be drawn on a map from the centre of Russian Tartary to the Bight of Benin, it will be found that north and east of this line the heads are of the brachycephalic type; south and west of it they are dolichocephalic; north and east the faces are orthognathous; south and west, prognathous. This, however, is a very broad statement of fact. Near these points may be found heads of all varieties of breadth; but, as a rule, the round-headed races, Mongols, Tartars, Turks (modified Tartars), are north of this line, and long-headed. Negro races are south and west of it.

These great changes are doubtless influenced by, and may be in great measure caused by, difference of physical condition. So great are the differences, that these points may be called the ethnological poles. At the northern end are cold, barren, treeless plains; at the southern, the warm, rank fertility of the tropics. As we go away from these ethnological poles, we find, in going from Tartary, the Chinese become longer-headed and more prognathous; the Greenlanders are long-headed; so are the Esquimaux; so are the North American Indians. In fact, all heads vary as we depart from the ethnological poles.

A line drawn from the British Isles, through Europe and Western Asia, to Hindostan, represents the Ethnological Equator, along which the skulls are found to be *oval*.

The question arises, whether the same varieties of the human race have always inhabited the regions of the earth in which they are now found. In Asia, in Africa, all remains that are found are of races similar to those now dwelling in the countries. In North America, in the valley of the Mississippi, are found, however, the remains of a race entirely different from those who now live there, — a race whose remains are the great earthworks found in that region.

When we come to Europe, however, we find, first of all, everywhere the remains of the great Roman people. In Northern Europe we find the remains of a long-headed people, acquainted with the use of iron, the ancestors of the present Germanic races. These, however, were preceded by a race smaller of stature, long-headed, like the Hindoos, unacquainted with the working of iron, — workers in *bronze*, — and traces of them are found all over Europe.

But *behind these*, and earlier than these, come the remains of an earlier race still, — a ruder race, — who possessed weapons of *stone* ground to an edge. These were a rounder-headed people, — the transverse measurement of the skull was eight-tenths of the longitudinal, — but the forehead was flat, the supra-orbital ridges were extremely prominent, and the jaws were prominent, though *not* decidedly prognathous.

At what distance from our epoch was this Stone Period? It is impossible to state in years. In Denmark, there are vast peat-bogs. In the upper layer of these are found *beech* trees, the trees which now form the forests of Denmark; and in these bogs are found the remains of the *iron age*. Deeper than these is a layer of peat, in which are imbedded *oaks* of enormous size, — oaks whose circumference speaks of centuries of growth. With the oak trees are found the implements of bronze. Deeper yet, is another stratum, in which are found pines, showing by their long stems that they have grown up in dense forests into which the light could hardly penetrate; and at the very bottom of these pine bogs are found the stone weapons. Under them, again, is found peat, in which are found no weapons of any kind, or any remains of man.

It is not possible to make any calculation of the years that have elapsed between the stone period and the present day, — the consideration of the immense length of time which must have been occupied in the formation of these bogs can alone furnish us with any idea on the subject. But before even these bogs were formed there was a time when the physical features of the country were totally different from what they now are, when the urus and bos primigenius, the fossil elephant, hyena, and cave bear roamed over the land. The question has arisen, was man contemporaneous with these animals? The recent numerous discoveries of stone weapons, chipped to an edge, and fossil bones acted upon by instruments, tend to the conclusion that man was coëxistent with these animals. The question then arises, what races of men? This has been answered by the discovery of a well-developed dolichocephalic human skull in a cave at Engis, in Belgium, associated with the remains of the animals enumerated above. Since that, a skull has been discovered at Neanderthal, near Düsseldorf, very different, and much lower in type than that of the Engis cave. It is a flat-topped skull, so much so that there was a question whether or not its shape had been produced by artificial means, and the supra-orbital ridges are extremely projecting.

An interesting question arises as to the relations which existed between the possessors of these skulls. Could they be all of one race, or were they of entirely different races? This question was settled by an examination of skulls which belonged to Australian aborigines,—the purest existing race of human beings. In a large collection of these, there were found skulls which almost exactly matched the Engis and the Neanderthal skulls in actual dimensions, and which certainly differed as much from each other in relative proportion as did these. A remarkable fact is, that the present aboriginal Australians resemble these ancient people in modes of life as well as in development of skull. Like them they use stone weapons; like them they use the bones of the kangaroo, as they did the bones of the deer and *urus;* like them they make mounds of refuse shells; and like them they build their huts on piles in the water.

The Engis skull can, however, be paralleled in proportions even by English skulls.

Far back as is the age of the men who made and used the flint implements, still farther removed is that at which must be placed the commencement of the human race.

A newly-discovered British "Bone Cave."—At the meeting of the British Association, 1862, Mr. Dawkins gave a description of a newly-discovered bone cavern in England, known as the "*Wookey Hole Hyena Den.*" After stating the peculiar features of the den,—its accidental discovery, its being filled up to the roof with *debris*, stones, and organic remains,—he showed the evidence of human occupation. In three areas in the cave he found ashes of bone, and especially of the rhinoceros tichorrhinus, associated with flint and chert implements of the same type as those of Amiens and Abbeville, and as those of the south-west of England. They were, however, of ruder workmanship, and possibly are of an earlier date. They were found underlying lines of peroxide of manganese and of comminuted bone, and overlying, in one of the three areas, remains of the hyena, which mark the old floors of the cave. From this he inferred that "man, in one of the earlier, if not the earliest stages of his being, dwelt in this cave, as some of the most degraded of our race do at present; that he manufactured his implements and his weapons out of flint, and arrow-heads out of more easily-fashioned bone. Fire-using, indeed, and acquainted with the use of the bow, he was far worse armed with his puny weapons of flint and bone than his contemporaries with their sharp claws and strong teeth. The very fact that he held his ground against them shows that cunning and craft more than compensated for the deficiency of his armament. Secondly, that as he was preceded in his occupation, so was he succeeded by the hyena. He then gave a brief summary of the organic remains found, comprising upwards of 1,000 bones, 1,015 teeth, and 156 jaws belonging to the lion, wolf, fox, bear of two species, badger, hyena, spelæa, ox, deer of six species, Irish elk, horse, and rhinoceros of two species. One of the latter, rhinoceros hemitœchus, stamps the date of the cave as belonging to the preglacial, while the rest of the organic remains belong to the fauna typical of the postglacial period.

ANCIENT REMAINS OF MAN IN SWITZERLAND.

The fact that on the shores of many of the Swiss lakes rows of stakes may be seen at a short distance from the land, through the water, emerging from the mud of the bed, has been long known.

No interest was, however, attracted to this phenomenon till about eight years since. At the end of 1853, the waters of the Lake of Zurich sank considerably, and the thrifty proprietors of land on the bank proceeded at once to add to their estates the portion of the lake-bed left bare, by constructing permanent dykes against the return of the water. While these works were being carried on, a row, or rather a system, of stakes was discovered at some little depth below the surface. Excavations were begun at this spot, and the result was to disinter a great variety of objects, which proved that a large number of human beings had once had their dwellings supported over the water by the stakes. Curiosity having been once aroused, researches were prosecuted not only at Obemeilen, where the first discovery was made, but all over Switzerland. It was gradually established that the mud near the shore of every Swiss lake supplied similar evidence. At some primeval period a population of very considerable density was shown to have lived in huts constructed on stages which rested on wooden supports driven into the bed, just as the Malays in Borneo and the Siamese at Bangkok may be seen living to this day. A wonderful number of articles pertaining to the daily life of these forgotten races have been brought to light. In some places, the materials of the dwellings have been preserved in the mud — the floor of hardened earth, and the twisted branches and bark which formed the walls. Arms have been discovered in great quantities, tools from saws in flint to needles in bone, ornaments, children's toys, the remains of stored-up fruits of various kinds, nay, even a cellar or receptacle full of corn, and a loaf of bread composed of bruised grain, and preserved by carbonization. By the side of these relics are found the bones of the animals whom they slew in the chase, many belonging to species extinct before the rise of history or barely mentioned in it. The urus, the bison, the elk, and the beaver, furnished them with food and with the materials for some of their most ingeniously constructed utensils. So plentiful and perfect are the remains found in the lakes that much more has been learned concerning the daily life and manners of men whose existence was not suspected ten years ago, than is known of races which have left a famous name in history or tradition.

It is no doubt startling at first sight that these archæological treasures should have been preserved in water rather than on land. But, now that the mud has given up its contents, it is not difficult for us to understand the service it has rendered. The truth is that the causes which help to conceal from us the monuments of our predecessors operate with far greater energy on land than in water such as fills the Swiss lakes. The reason why the relics of former generations are comparatively scarce is not that they are destroyed so much as that they are buried. Rubbish and dust are, in short, the great obscurers of the past. When successive generations continue to inhabit the same spot, each buries not only the bodies but the whole life of its predecessors. Rome is built on countless strata composed of former cities, and not a few destroyed Londons support the London of the present moment. Even when a town or village is once for all deserted, the process of destruction is rapid. Rain and wind level the walls, dust is whirled into the hollows, buildings melt together, and nothing but a protuberance on the plain remains to mark the site of a Babylon or a Nineveh. If, then, this is the fate of cities built in stone or brick, it ceases to be wonderful that monuments of the older races who made their dwellings of wood, or, still earlier, of wattled branches, should have altogether disappeared on land. The interest of the Swiss discoveries arises from the mitigation, in this particular instance, of the destroying forces. The materials and contents of the huts doubtless sank into the lake from the piles on which they rested, and lay on the bottom in an undistinguishable heap. The belief, indeed, of the Swiss antiquaries is that they were violently destroyed at various epochs. But the water into which they fell was still and calm. It did not wash them away, but year after year deposited over them a coat of mud, infinitely thinner and softer than the layers of rubbish which cover the memorials of a later time. The bed of each of these lakes is known, in fact, from independent observations, to be slowly rising; and, since the recent discoveries, attempts have been made to calculate the rate of its elevation, so as to derive approximately the age of the remains from the depth at which they are found. Some fragments of a Roman construction in the lake at Yverdun, of which the date is known, have supplied the basis of a calculation which has carried back the existence of the most ancient inhabitants of Switzerland to fifteen centuries at least before the Christian era.

The Swiss antiquaries would not be men of their day if they had not constructed a minute and detailed history of the race they have unburied. Their pursuits, their religions and revolutions are boldly described by their discoverers. Soberer inquirers will limit considerably the number of inferences which may be drawn from the remains. These extinct populations may be believed to have been partly agricultural, but their chief subsistence was derived, no doubt, from hunting. They had some regular industrial pursuits, for fragments of rude pottery have been found on several sites. That they were engaged in perpetual war is tolerably certain from the quantity of weapons found, and from the very circumstance of their securing themselves from surprise by building their villages on piles in the water. Certain of the monuments seem to have had a religious character, and to betoken some kind of religious belief. As to their history, the only evidence for creating it is identical with that which enables us to infer a certain progress among all the primeval races of Europe. Among the extinct populations of Switzerland, as in those of other parts of Europe, there was an age of flint, an age of bronze, and an age of iron. In certain villages, situated chiefly in Eastern Switzerland, all the utensils are of flint, fashioned by observing the natural cleavage, and the wood used bears the marks of the rude tools which had been long and painfully employed in cutting it. Other sites contain articles of bronze, and the pottery here found is less rude than that discovered among the population of the age of flint; it even presents some traces of a rough ornamentation. The plentifulness of bronze at such a time and in this part of Europe is not a little curious. Both the tin and the copper which compose it must have been brought from a great distance, and their presence singularly confirms Sir G. C. Lewis's theory of the antiquity of the overland trade from Britain through Gaul, more particularly as ornaments of coral and amber are found in villages of the same apparent age. The last of the eras indicated is that of iron. Ancient tools and other articles of iron are abundant in Western Switzerland, and exactly resemble those found in Gaul.

There is a fair probability that the three ages succeeded each other in the order in which they are usually placed. It is likely that human skill was first exercised on stone, and more than probable that the metals earliest used were copper and tin, both of which are distinguished for the ease with which they are obtained, particularly until the surface supply is exhausted. The difficulty arising from the fact of their being found in very few localities is diminished when the antiquity of the trade in them is assumed on independent grounds. The uses of iron, the most widely diffused but the hardest to work of the metals, might be expected to be last of all discovered by mankind. The heroes of Homer, for instance, lived chiefly in the age of bronze, but had hardly entered on that of iron. Whether, so far as the Swiss races are concerned, the three eras succeeded each other abruptly, or melted gradually into one another, is a question which there is little or no evidence to decide. The antiquaries of Switzerland insist that they can trace two great revolutions. The men of bronze suddenly invaded the country and extirpated the men of flint, to be afterwards in their turn extinguished by the men of iron. No doubt most of the villages were violently destroyed when they ceased to be inhabited; but why attribute to enemies with iron weapons what may quite as well have been done by foes armed with flint? In justice, however, to the Swiss theory, it must be added that the men of iron appear from their instruments to have been a Celtic race from Gaul, and from the size of their ornaments to have possessed larger and stronger frames than the earlier populations. As the Helvetians of history are known to have been a Celtic race, they may have been the invaders in question, who, after extirpating an aboriginal people, may have continued to occupy the country down to Roman times.

THE ANTIQUITY OF THE "STONE," "BRONZE," AND "IRON" AGES OF EUROPE.

Some attempts have recently been made by the Swiss archæologists to estimate the duration and antiquity of those periods in the history of man which have been respectively designated as the "Stone," "Bronze," and "Iron" ages or periods of Europe.

The torrent of the stream Tinière, at the point where it falls into the Lake of Geneva, near the town of Villeneuve, has gradually built up a cone of gravel and alluvium. In the formation of a railway this cone has been recently bisected for a length of 1,000 feet, and to a depth in the central part of about 32 feet above the level of the rails. The section of the cone thus obtained shows a very regular structure, which proves that its formation was gradual. It is composed of the same materials (sand, gravel, and larger blocks) as are even now brought down by the stream. The detritus does indeed differ slightly from year to year, but, in the long run, the differences compensate for one another; so that, when considering long periods and the structure of the whole mass, the influence of these temporary variations, which arise from meteorological causes, altogether disappears, and need not, therefore, be taken into account. Documents preserved in the archives of Villeneuve show that, in the year 1710, the stream was dammed up and its course a little altered, which makes the present cone slightly irregular. That the change was not of any great antiquity is also shown by the fact that, on the side where the cone was protected by the dykes, the vegetable soil, where it has been affected by cultivation, does not exceed two to three inches in thickness. On this side, thus protected by the dykes, the railway cutting has exposed three layers of vegetable soil, each of which must, at one time, have formed the surface of the cone. They are regularly intercalated among the gravel, and exactly parallel to one another, as well as to the present surface of the cone, which itself follows a very regular curve. The first of these ancient surfaces was followed, on the south side of the cone, over a surface of 15,000 square feet; it had a thickness of four to six inches, and occurred at a depth of about four feet (1.14 metre measured to the base of the layer) below the present surface of the cone. This layer belonged to the Roman period, and contained Roman tiles, and also a coin.

The second layer was followed over a surface of 25,000 square feet; it was six inches in thickness, and lay at a depth of 10 feet (2.97 metres, also measured to the bottom of the layer). In it have been found several fragments of unvarnished pottery, and a pair of tweezers in bronze, which, to judge from the style, belonged to the "Bronze" epoch. The third layer has been followed for 3,500 square feet; it was six or seven inches in thickness, and lay at a depth of 19 feet (5.69 metres) below the present surface; in it were found some fragments of very rude pottery, some pieces of charcoal, some broken bones, and a human skeleton, with a small, round, and very thick skull. Fragments of charcoal were even found a foot deeper, and it is also worthy of notice that no trace of tiles was found below the upper layer of earth.

Towards the centre of the cone, the three layers disappear, since, at this part, the torrent has most force, and has deposited the coarsest materials, even some blocks as much as three feet in diameter. The farther we go from this central region the smaller are the materials deposited, and the more easily might a layer of earth, formed since the last great inundations, be covered over by fresh deposits. Thus, at a depth of ten feet in the gravel on the south of the cone, at a part where the layer of earth belonging to the "Bronze" age had already disappeared, two unrolled bronze implements were discovered. They had probably been retained by their weight, when the earth, which once covered them, was washed away by the torrent. After disappearing towards the centre of the cone, the three layers reappear on the north side, at slightly greater depth, but with the same regularity and the same relative position. The layer of the "Stone" age was but slightly interrupted, while that of the "Bronze" era was easily distinguishable by its peculiar character and color.

Here, therefore, we have phenomena so regular and so well marked that we may apply to them a calculation, with some little confidence of at least approximate accuracy. Making, then, some allowances, for instance, admitting three hundred years instead of one hundred and fifty for the period since the embankment, and taking the Roman period as representing an antiquity of from sixteen to eighteen centuries, we should have for the age of "Bronze" an antiquity of from 2,900 to 4,200 years; for that of the "Stone" period from 4,700 to 7,000 years; and for the whole cone, an age of from 7,400 to 11,000 years. M. Morlot thinks that we should be most nearly correct in deducting two hundred years only for the action of the dykes, and in attributing to the Roman layer an antiquity of sixteen centuries, that is to say, in referring it to the middle of the third century. This would give a period of 3,800 years for the "Bronze" age, and 6,400 years for that of "Stone;" but, on the whole, he is inclined to suppose for the former an antiquity of from 3,000 to 4,000 years, and for the latter of from 5,000 to 7,000 years.

In the remains of a settlement at the foot of Mt. Chamblon, in Switzerland, we have, according to M. Troyon, a Swiss archæologist, another instance in which we are able to obtain at least an approximation to a date of the above-referred-to ages. The interest which attaches to this case arises from the fact that pile-works, intended for the support of ancient habitations over the water, have been found in the peat at a considerable distance from the lake, whereas it is evident that, at the time of their construction, the spot in which they occur must have been under water, as this mode of building would have been quite out of place on dry land. This, however, indicates a very considerable antiquity, since the site of the ancient city Eburodunum must have been, at that time, entirely covered by the lake; and yet the name, which is of Celtic origin, denotes that there was a town here even before the Roman period. In order, however, to form an idea of the time at which the dwellings at Chamblon were left dry by the retirement of the lake, we must have in the valley a point of determined age to serve as a term of comparison; and such a point we find in the ancient city of Eburodunum (Yverdon), which was built on a *dune* extending from Jorat to the Thiéle. Between this *dune* and the lake, on the site at present occupied by the city of Yverdon, no traces of Roman antiquities have ever been discovered, from which it is concluded that it was at that period under water. If, then, we admit that, at the close of the fourth century, the lake washed the walls of the Castrum Eburodense, we shall have fifteen centuries as the period required to effect this change. The zone thus uncovered in fifteen hundred years is 2,500 feet in breadth, and, as the piles at Chamblon are at least 5,500 feet from the water, it may be inferred that three thousand three hundred years must have elapsed since they were left dry. This lake dwelling belonged to the "Bronze" period, and the date thus obtained agrees pretty well with that obtained from the examination of the Cone de la Tinière. — *Lubbock on the Ancient Lake Habitations of Switzerland.*

AGE OF THE PYRAMIDS.

An Egyptian astronomer, Mahomed Bey, has recently published a remarkable work on the age and the objects of the Pyramids, as elucidated by the star Sirius. His labors were undertaken last spring, for the purpose of verifying the exact orientation of these vast funereal piles. The measurements made by him have given 231 metres for the length of the sides of the square base of the Great Pyramid, and 146.5 metres for its height; whence it follows that the angle its faces make with the horizon is 51° 45′. Comparing this with the known inclinations of six other pyramids at Memphis, the constancy of this angle, which is always confined between 51° and 53°, and on the average 52° 30′, is very remarkable. This invariable inclination, combined with the exact orientation of the pyramids, has led to the idea that there was some hidden connection between their form and some celestial phenomenon, and consequently with the divinity who presides there according to the Egyptian mythology. Now, it is found that the star Sirius, when it passes the meridian of Gezah, falls directly upon the southern face of the pyramids, and in calculating the change of position of this star, during a succession of ages, the result has been found that, 3,300 years B C., its rays, when they culminated, fell exactly perpendicularly to the southern face of the pyramids inclined 52° 5′ to the northern horizon. But, according to the principles of astrology, the power of a star has its maximum effect when its rays fall perpendicularly upon the object which it is deemed to influence. Thus, supposing that the pyramids have been constructed 5,000 years, it appears evident that their faces received the inclination of 52° for the purpose of being struck normally by the rays of the most beautiful star in our heavens, and which was consecrated to the god Sothis, — the "dog-star" and judge of the dead. This opinion is confirmed in an unexpected way. The pyramids, being tombs or funereal monuments, ought to be found under the patronage of the divinity whose chief connection is with the dead, that is, with Sothis; and, moreover, the hieroglyphical symbol of Sothis is a pyramid at the side of a star and a crescent. On the other hand, Sirius was, according to the Egyptians, the soul of Sothis. The date of the foundation of the pyramids, as resulting from these investigations, accords with the computation of Bunsen, according to which King Cheops reigned in the thirty-fourth century before our era.

BOTANY.

RAPID GROWTH OF VEGETABLES IN HIGH LATITUDES.

In a recent treatise on the vegetable productions of Norway, Dr. Mueller relates some extraordinary facts respecting the influence of the long duration of light, during the summer months, on the growth of vegetables in the higher latitudes of Norway. At 70° N. it was found that peas grew at the rate of three and a half inches in twenty-four hours for many days in summer, and that some of the cereals also grew as much as two and a half inches in the same time. Not only is the rapidity of growth affected by the constant presence of light, but those vegetable secretions which owe their existence to the influence of actinic force on the leaves are also produced in far greater quantity than in more southern climates; hence the coloring matter and pigment cells are found in much greater quantity, and the tint of the colored parts of vegetables is consequently deeper. The same remark applies to the flavoring and odoriferous matters; so that the fruits of the north of Norway, though not equal in saccharine properties, are far more intense in flavor than those of the south.

NATURE OF THE GAS PRODUCED FROM DECOMPOSITION OF CARBONIC ACID BY LEAVES EXPOSED TO LIGHT. BY M. BOUSSINGAULT.

Referring to the history of discovery in respect to the relations of plants to the atmosphere, Boussingault remarks that Bonnet first took notice of the emission of air from the surface of leaves; Priestly recognized this air to be oxygen; Ingenhouse proved the presence of light to be necessary; and Senebier proved that the oxygen gas eliminated by leaves under the light of the sun came from the decomposition of carbonic acid gas. Saussure, nearly at the beginning of the present century, ascertained the fact — which has often been overlooked — that the volume of oxygen gas produced was not quite equal to that of carbonic acid decomposed; and also that nitrogen gas was always evolved to an amount of the oxygen gas which had somehow disappeared. He supposed that this nitrogen came from the substance of the plant, not considering, what is now obvious, that the substance of the plant did not contain, and therefore could not have furnished, anything like this quantity of nitrogen.

In modern times, Daubeny was unable to obtain from leaves oxygen gas free from azote; and Draper states that he found the astonishing amount of from twenty-two to forty-nine per cent. of the gas emitted from the leaves of *Pinus tæda* and *Poa annua* to be nitrogen. The first step towards the elucidation of the matter was made by Cloez and Gratiolet, who, exposing the leaves of a common pond weed in water, slightly impregnated with carbonic acid, found the first day 15.70 per cent. of the gas eliminated was nitrogen ; the second, 13.79 ; the third, 12.00 ; the fourth, 10.26 ; the fifth, 9.53 ; the sixth, 8.15 ; the 8th, 2.90. That is, the oxygen gas grew purer and purer, exactly as if the azote retained in the tissues of the plant, or in the water, was gradually expelled by the oxygen. Similar experiments were made by Boussingault, in 1844, confirming these results ; and also, later, a set of comparative experiments, with and without leaves, which confirmed the truth of the conjecture as to the source of most of the nitrogen. But, after all, he could not obtain any oxygen gas free from azote.

Boussingault now devised a new method of proceeding, by which he avoided the difficulty about extraneous nitrogen, etc. The mean results of twenty-five experiments, — which are detailed particularly in the memoir, — made with a variety of plants, are, that 100 measures of carbonic acid gas, decomposed by foliage under the light, give 97.2 of oxygen gas ; and that 1.11 of azote had appeared, which, from the plan of the experiments, could not have come from the water, nor have been contained in the plant.

At this point, Boussingault raised the question whether this gas, which remained after the absorption of the oxygen by the pyrogallate and the carbonic acid by potassa, was necessarily and really nitrogen. A suite of experiments, devised and executed in this view, brought out the interesting result that the supposed azote, which, moreover, corresponded very nearly with the amount of oxygen gas that had disappeared, was oxide of carbon, that is, carbonic oxide ! There is also a little protocarburet of hydrogen. So, "foliage during the decomposition of carbonic acid does not really emit nitrogen gas, but with the oxygen gas emits some oxide of carbon and some protocarburet of hydrogen, and these combustible gases, like the oxygen, are produced only under the light of the sun. . . . In other terms, to keep strictly within the conditions of the experiments, these gases constantly accompany the oxygen of which the sun determines the production, when it acts upon a vegetable submerged in water impregnated in carbonic acid." Is this also the case when carbonic acid is decomposed by foliage in the air ?

Boussingault concludes his paper with the remark, that the earlier observers looked at their discoveries rather from the hygienic than the physiological point of view ; that, while Priestly announced his brilliant discovery by the statement that plants purify the air vitiated by combustion or by the respiration of animals, it is curious enough that a century afterwards it should come to be demonstrated, before the Academy of Sciences, that probably the leaves of all plants, and certainly those of aquatic plants, while emitting oxygen gas, which ameliorates the atmosphere, also emit one of the most deleterious of known gases, carbonic oxide ! He closes with the pregnant and natural query, whether the unhealthiness of marshy districts is not attributable, at least in part, to the disengagement of this pernicious gas by plants.

We add, that what strikes us with most surprise, is to learn that if these results are true, the vegetable machinery would seem to work at a loss, and with a real, though it be a small, waste of material! When any carbonic acid taken into the leaves passes off unchanged, so much work is not done; but there is no waste or loss in the process of manufacture. But, looking at the food of plants and their products, — comparing the raw material with the manufactured article, — it seems apparent that any carbonic acid which is reduced to carbonic oxide, and given off as such, is so much loss or waste! We may avoid this unwelcome conclusion by the supposition that the carbonic oxide and carburet of hydrogen are products of the decomposition of some of the vegetable matter coëtaneous with vegetable assimilation, but no part of that process itself. This is the more probable, since it cannot reasonably be supposed that carbonic acid supplied to the foliage is resolved into oxygen and carbonic oxide and both set free, — which seems to be the alternative.

REPRODUCTION OF ORCHIDS.

Much curious information in relation to the above subject has been brought out by Mr. Darwin, the well-known English naturalist, in a recently-published work. Of these curious plants, it is stated that 433 genera, including about 6,000 species, are now known; and, as may be readily imagined, the natural provision for their reproduction is strikingly efficient. Of this, Mr. Darwin testifies from his own observation. He says: —

"I was curious to estimate the number of seeds produced by orchids; so I took a ripe capsule of *Cephalanthera grandiflora*, and arranged the seeds as equably as I could in a narrow hillock, on a long ruled line, and then counted the seeds in a length, accurately measured, of one-tenth of an inch. They were 83 in number, and this would give for the whole capsule 6,020 seeds; and for the four capsules borne by the plant 24,000 seeds. Estimating in the same manner the smaller seeds in *Orchis maculata*, I found the number nearly the same, viz., 6,200; and, as I have often seen above 30 capsules on the same plant, the total amount will be 186,300, — a prodigious number for one small plant to bear. As this orchid is perennial, and cannot in most places be increasing in number, one seed alone of this large number, once in every few years, produces a mature plant. I examined many seeds of the Cephalanthera, and very few seemed bad. To give an idea what the above figures really mean, I will briefly show the possible rate of increase of *O. maculata*. An acre of land would hold 174,240 plants, each having a space of six inches square, which is rather closer than they could flourish together; so that, allowing 12,000 bad seeds, an acre would be thickly clothed by the progeny of a single plant. At the same rate of increase, the grandchildren would cover a space slightly exceeding the island of Anglesea; and the great-grandchildren of a single plant would nearly (in the proportion of 47 to 50) clothe with one uniform green carpet the entire surface of the land throughout the globe!"

Mr. Darwin has also ascertained that self-fertilization is a very rare event with orchids, and that most species, through a curious provision of nature, absolutely require the aid of insects for their reproduction.

This is obvious from such an arrangement of the organs that the pollen-mass (pollinium) and other connected parts are too closely embedded to be shaken out by violence. Somehow, the precious pollen must be transferred; the little grains, so reproductive when properly applied, would be useless in their original position. They are there with all their natural fertilizing qualities, but they must be elsewhere before these can be serviceable. What is to transport them if they cannot be shaken out by a gentle violence? Try Mr. Darwin's experiment, and you will arrive at his conclusion. He covered one plant under a bell-glass before any of its pollinia had been removed, and he left three adjoining plants uncovered. Frequent examinations disclosed the fact that some of the pollinia were daily removed from the uncovered plants until nearly all were gone, while all the pollinia remained firm in the cells of the glass-covered plant. Other observations tend to a like result. From all of them it may be inferred that there probably is a proper season for each kind of orchis, and that insects cease from their visits to it after the proper season has passed, and the regular secretion of nectar has ceased.

The evidence of insect visitation is not derived from their detection in the flowers; and it is a curious circumstance that, although Mr. Darwin has been in the habit for twenty years of watching orchids, he has never seen an insect actually visit a flower, excepting, indeed, some butterflies on two occasions. We are to look for the evidence of their visitations, not by attempting to detect the insects in the act, but by discovering the stolen goods, the pollinia, upon their bodies. This Mr. Darwin has especially observed in the case of moths, who are attracted, with other insects, by the peculiarly sweet nectar secreted by the orchis flowers.

The nectar-secreting apparatus in some species is very curious. In one species, the *Coryanthis*, two little horns near the straplike junction of the labellum with the base of the column secrete so much limpid nectar, having a slightly sweet taste, that it slowly distils, and a single flower will in all secrete about an ounce weight. The most remarkable appendage is that of the deeply-hollowed end of the labellum, which hangs some way down, exactly beneath the two little horns, and catches the drops as they fall, precisely like a bucket suspended some way beneath a dripping spring.

In fact the arrangement for seducing the insects to visit and alight upon the flowers is in some cases so ingenious that Mr. Darwin, in describing it, exclaims: "A poet might imagine that whilst the pollinia are borne from flower to flower, adhering to a moth's body, they voluntarily and eagerly place themselves, in each case, in that exact position in which alone they can hope to gain their wish and perpetuate their race."

The special adaptation of parts for the fertilization of *Listera ovata* is clearly unfolded, and worth attentive study: — "The anther-cells open early, leaving the pollen-masses quite loose, with their tips resting on the concave crest of the rostellum. The rostellum then slowly curves over the stigmatic surface, so that its explosive crest stands at a little distance from the anther; and this is very necessary, otherwise the anther would be caught by the viscid matter, and the pollen forever locked up. This curvature of the rostellum over the stigma and base of the labellum is excellently well adapted to favor an insect striking the crest when it raises its head, after having crawled up the labellum, and licked up the last drop of nectar at its base. The crest of the rostellum is so exquisitely sensitive that a touch from a most minute insect causes it to rupture at two points, and instantaneously twó drops of viscid liquid are expelled, which coalesce. This viscid fluid sets hard in so wonderfully rapid a manner that it rarely fails to cement the tips of the pollinia, nicely laid on the crest of the rostellum, to the insect's forehead. The pollen-masses, when once cemented to an insect's forehead, will generally remain firmly attached to it until the viscid stigma of a mature flower removes these encumbrances from the insect, by rupturing the weak elastic threads by which the grains are tied together, receiving at the same time th benefit of fertilization."

Mr. Darwin also describes the curiously constructed arrangements for reproduction existing in the *male* flowers of another variety of orchids, viz., the *Catasetum*. It is necessary that the pollen-masses of these flowers be transported to female plants in order that seed may be produced. Now, in these male flowers, the pollinium is furnished with a viscid disc of huge size; but the disc, instead of being placed, as in other orchids, in a position likely to touch and adhere to an insect visiting the flower, is turned upwards and lies close to the upper and back surface of a chamber, which must be called the stigmatic chamber, though functionless as a stigma. There is nothing in this chamber to attract insects; and even if they did enter it, it is hardly possible that the disc should adhere to them, for its viscid surface lies in contact with the roof of the chamber. How then does nature act? She has endowed these plants with what must be called, for want of a better term, sensitiveness, and with the remarkable power of forcibly ejecting their pollinia to a distance. Hence, when certain definite points of the flower are touched by an insect, the pollinia are shot out like an arrow which is not barbed, but has a blunt and excessively adhesive point. The insect, disturbed by so sharp a blow, or after having eaten its fill, flies sooner or later to a female plant, and, whilst standing in the same position as it did when struck, the pollen-bearing end of the arrow is inserted into the stigmatic cavity, and a mass of pollen is left on its viscid surface. Thus, and thus alone, species of the genus Catasetum are fertilized."

Notwithstanding the immense seed-produce of orchids, the greatest care is taken throughout this vast order, with its more than four hundred genera and its six thousand species, that the pollen shall not be wasted; and yet, so far as all observation goes, the act of fertilization is for the most part left to insects. In commenting on this curious circumstance, Mr. Darwin uses the following language: — "Considering how precious the pollen of orchids evidently is, and what care has been bestowed on its organization and on the accessory parts, — considering that the anther always stands close behind or above the stigma, self-fertilization would have been an incomparably safer process than the transportal of the pollen from flower to flower. It is an astonishing fact that self-fertilization should not have been an habitual occurrence. It apparently demonstrates to us that there must be something injurious in the process. Nature thus tells us, in the most emphatic manner, that she abhors perpetual self-fertilization. This conclusion seems to be of high importance; and may we not further infer as probable, in accordance with the belief of the vast majority of the breeders of our domestic productions, that marriage between near relations is likewise in some way injurious, — that some unknown great good is derived from the union of individuals which have been kept distinct for many generations?"

THE UGLIEST PLANT IN EXISTENCE.

At a recent meeting of the Linnæan Society, London, Dr. J. D. Hooker described a new plant, which he characterized as not only structurally the most peculiar, but it is probably the ugliest plant that has ever been seen. It was discovered by Dr. Welwitsch beyond the northern limits of Cape Town, Southern Africa, and has received the name of *Welwitschia mirabilis.* It is a stunted-looking kind of tree, whose summit never reaches more than two feet above the level of the ground, whilst its short woody trunk never possesses more than two leaves. These extraordinary leaves are, in point of fact, the expanded seed-lobes, or cotyledons, which make their appearance as soon as the young plant rises out of the ground; and, what is still more astonishing, these aforesaid leaves live, grow, and remain attached to the stumpy trunk during the entire life of the tree, which, it is calculated, lives at least one hundred years. We may also further observe that these two persistent foliar organs spread out laterally, in some fine examples of the *Welwitschia* attaining, each of them, a length of nearly six feet. The flowering axes shoot up from the summit of the stumpy trunk, which is flattened at the top, and like a folded card-table is divided by a central line into two equal halves. The root is conical, and longer than that part of the trunk which appears above ground. There are many other points of peculiar scientific interest connected with the form and structure of this astonishing plant.

ZOOLOGY.

VELOCITY OF THE NERVE FORCE.

At the September (1862) meeting of the *Société Helvetique des Sciences Naturelles*, M. Hirsch exhibited an apparatus for determining what astronomers call the *personal equation* of time, or the difference which observers make from personal causes in the estimation of minute periods. He said, "We have now introduced the electric method into astronomical observation, and as the observer has only to shut off the current as soon as he sees the bisection of a star, the problem of personal equation consists in determining the time which is necessary for the astronomer to see and execute the necessary movement of his finger. This time, which we call physiological time, consists of three elements: 1. The time occupied in transmitting the impression to the brain; 2. The time taken by the brain to transform the sensation into a volition, and, 3, that consumed in transmitting this volition through the nerves, and in the execution of the muscular movement." To ascertain these minute periods, M. Hirsch employs the chronoscope of M. Hipp. A ball is so arranged that its fall interrupts an electric current, and thus sets free the motion of certain hands. As soon as an observer perceives the fall of the ball, he remakes the contact, and arrests the hands, whose motion in the interval gives the physiological time. By the use of this instrument M. Hirsch has come to the conclusion that nerves transmit their impressions at the rate of thirty-four metres a second. Mr. Heimholz estimated their velocity at one hundred and ninety feet per second, but his experiments were on the motor nerves of frogs, and those of M. Hirsch on the sensitive nerves of man.

HAIRLESS MEN OF AUSTRALIA.

The Sydney *Empire* (Australia), of February 19th, 1862, publishes the following curious account of a race of bald men, recently discovered in that island-continent. It says: —

"It is now some few years since a report first obtained currency, that, far in the western interior, beyond the Balonne River, a tribe of aboriginal natives existed who exhibited remarkable physical distinctions from those with whom explorers and other colonists have so long been familiar. It was said that the natives in question were entirely destitute of hair, even on the head, which was as bald as a billiard-ball. Other remarkable peculiarities were also mentioned, but the absence of ocular proof led most people to doubt them, and it was pretty generally believed that either the blacks alluded to were merely suffering from some cutaneous disorder, or the tale was one of those bush 'yarns' with which settlers think it no harm to hoax the townsman. Yesterday, however, we had an opportunity of ascertaining that all the statements were perfectly true. Mr. M'Kay, a gentleman just arrived from the Balonne River, called at our office with one of these natives. He is a young man, according to Mr. M'Kay's belief, only about sixteen or seventeen years of age, but certainly looking much older. His head is entirely destitute of hair, nor is there any trace of hirsute honors on his body. There was a black, ingrained appearance on the scalp as if the roots of hair remained, but Mr. M'Kay states that this is merely the traces of a dirty cloth which he was in the habit of wearing on his head. There needed not, however, this remarkable destitution of hair to show that the individual before us was the type of a race utterly differing in physical peculiarities from the ordinary aboriginals of Australia. The whole contour of the face, form of the head, expression, color of skin, and listless, almost sullen attitude, at once suggested the Mongolian. His physical development is far inferior to that of the healthy aboriginal found in other parts of Australia. The large, rapid eye, thick lips, broadly-spread nose, and deep brown skin, were all absent. The peculiarity of the face was most evidently Chinese, and the eye confirmed this impression. The skin of this interesting stranger is precisely of that deep yellow-brown shade which might be expected in a descendant from Chinese and aboriginal Australian parents. The party to whom he belonged — for there is no clear reason for calling it a tribe — appeared to inhabit the country to the north-westward of the Upper Warrego. Mr. M'Kay had not seen more than six or seven of them at various times, one, at least, of whom was a woman, and one man was much taller and more strongly proportioned than the specimen brought to our office. The whole circumstances of the case render it extremely probable that these remarkable people are the descendants of Chinese fishermen, who, having, years ago, landed or been cast away in the Gulf of Carpentaria, or on the Australian coast of the Arafura Sea, have remained with the Australian aborigines, and transmitted the physical peculiarities of their race to their descendants."

THE ZOOLOGICAL SIGNIFICANCE OF THE BRAIN AND LIMB CHARACTERS OF MAN.

The following is a report of an interesting discussion on the relative position of man and monkeys which took place at the last meeting of the British Association (1862), between several well-known naturalists. Prof. Owen commenced the discussion by exhibiting and contrasting the brain of a man and the brain of a gorilla. The differences between them he pointed out as follows: — In the brain of man, the posterior lobes of the cerebrum overlapped, to a considerable extent, the small brain, or cerebellum; whereas in the gorilla the posterior lobes of the cerebrum did not project beyond the lobes of the cerebellum. The posterior lobes in the one were prominent and well marked; in the other, deficient. These peculiarities had been referred to by Todd and Bowman. From a very prolonged investigation into the characters of animals, he felt persuaded that the characters of the brain were the most steadfast; and he was thus induced, after many years of study, to propose his classification of the mammalia, based upon the differences in the development of their brain structure. He had placed man — owing to the prominence of the posterior lobes of his brain, the existence of a posterior cornu in the lateral ventricles, and the presence of a hippocampus minor in the posterior cornu — in a distinct sub-kingdom, which he had called Archancephala, between which and the other members of the mammalia the distinctions were very marked, and the rise was a very abrupt one. The brain, in his estimation, was a far better guide in classifying animals than the foot; but the same difference that existed between their brains was also observable between their feet.

Prof. Huxley observed, that Prof. Owen's statements appeared to him in no way to represent the real nature of the problem under discussion. He would, therefore, put that problem in another way. The question was partly one of facts, and partly one of reasoning. The question of fact was, What are the structural differences between man and the highest apes? — the question of reasoning, What is the systematic value of those differences? Several years ago, Prof. Owen had made three distinct assertions respecting the differences which obtained between the brain of man and that of the highest apes. He asserted that three structures were "peculiar to and characteristic" of man's brain — these being the "posterior lobe," the "posterior cornu," and the "hippocampus minor." In a controversy which had lasted for some years, Prof. Owen had not qualified these assertions, but had repeatedly reiterated them. He (Prof. Huxley), on the other hand, had controverted these statements; and affirmed, on the contrary, that the three structures mentioned not only exist, but are often better developed than in man, in all the higher apes. He (Prof. Huxley) now appealed to the anatomists present if the universal voice of Continental and British anatomists had not entirely borne out his statements and refuted those of Prof. Owen. Prof. Huxley discussed the relations of the foot of man with those of the apes, and showed that the same argument could be based upon them as on the brain; that argument being, that the structural differences between man and the highest ape are of the same order and only slightly different in degree from those which separate the apes one from another. In conclusion, he expressed his opinion of the futility of discussions like the present. In his opinion, the differences between man and the lower animals are not to be expressed by his toes or his brain, but are moral and intellectual. Prof. Rolleston said he would try and supply the members of the Association with the points of positive difference between the human and the ape brain. For doing this we had been abundantly shown that the hippocampus minor and the posterior lobe were insufficient. As differentive, they must be given up at last. This analysis of the brain's structure had established as differentive between man and the ape four great differences — two morphological, two quantitative. The two quantitative are the great absolute weight and the great height of the human brain; the two morphological, the multifidity of the frontal lobes corresponding to the forehead, usually, popularly, and, as this analysis shows, correctly, taken as a fair exponent of man's intelligence, and the absence of the external perpendicular fissure. This had been abundantly shown by Gratiolet. Mr. W. H. Flower, looking at the subject solely in the anatomical view and as a question of fact, stated that the result of a considerable number of dissections of brains of various monkeys was that the distinction between the brain of man and monkeys did not lie in the posterior lobe or the hippocampus minor, which parts were proportionately more largely developed in many monkeys than in man, and that if these parts were used in the classification of man and the monkeys the series would be, first, the little South American marmosets; then would follow the baboons, the cercopithea, macaque; then man must be placed, followed by the anthropoid apes, the orang-outang, chimpanzee, and gorilla; and last, the American howling monkey.

In reviewing the above discussion, the London *Times* uses the following language: — We are firmly persuaded that these discussions, interesting as they may be to physiologists, can never teach the rest of us anything which it concerns us to know. The possession by man of certain distinctive attributes transcending the highest intelligence of animals, as organic transcends inorganic life, is a fact beyond doubt or qualification. The method by which he became possessed of these attributes is a mystery, and must ever remain so. It is conceivable, though improbable in the highest degree, that scientific research may discover what has been presumptuously called "the missing link" between the human skeleton and the skeleton of the highest class of apes; but what will have been gained by such a revelation? Nothing, except an evidence that the external form of two orders of beings differing in all that can constitute a difference of nature may approximate more closely than has hitherto been supposed. The step from resemblance to filiation is one that can never be made legitimately, and, if it could, the only problem that has more than a scientific interest would remain unsolved. The history of the human race must begin with the first creature endowed with a human soul, and no structural affinity will ever justify us in acknowledging as man a being which has left no traces of reasonable agency. Between the highest efforts of instinct and the rudest manufactured implements which geologists have detected in caves or gravel-beds, there is an interval which cannot be bridged over. While we are what we are, and learn from history and philology that no material change has passed over our mental organization since language was used to express thought, we can dispense with the assumption that our physical organization is unique. Experience had already told us that we live under the same physical conditions with other animals. Like them, we need air, sleep, and food; the constituent parts of our bodies and the mode of growth are the same; the processes of digestion and secretion, and the tendency to disease, are common to us with them, and we share with them all the senses and many of the affections. It is a small thing, then, to admit the existence of other features of similarity such as osteology attests. The recognition of these features is as old as Aristotle, and the use now made of them comes too late to shake our faith in our pretensions to an exclusive rank among animals. That we should unite a conscience and a spiritual nature with a bodily framework inferior in strength and little superior (if it be so) in delicacy to some other mammalia, would be the strongest possible confirmation of our title to this rank. Nor would this title be the least affected by any theory about the mode of our creation, gratuitous and worthless as such a theory must ever be. There would be nothing more derogatory to Omnipotence, or even to human nature, in the conjecture that man did not become a living soul till he had passed through several lower stages of animal life, than in the doctrine that he was formed immediately out of the dust of the ground; nor would he cease to be a little lower than the angels if the elements of his body could be analyzed into an original monad. The difference between the two views is that we have the highest authority known for the one, while the other has no basis but a set of disputed facts which cannot possibly prove more than that something which was not human once existed in human shape. It is one thing to show that a brute may have organs as perfect as a man; it is another thing to prove that man is nothing but a highly-educated brute.

ZOOLOGICAL SUMMARY.

Absorbing Power of the Human Skin. — Dr. Murray Thomson, lecturer on chemistry at the Edinburgh School of Medicine, relates some experiments which he tried on his own person to ascertain the truth of the statements made as to the curative power of mineral water baths, depending on the absorption by the skin of certain salts and other substances which they hold in solution; and, further, to ascertain whether certain substances applied in the form of ointments, etc., pass through the skin and reach the blood before they produce any beneficial effect. His conclusions are:—"Not only has absorption by the skin been greatly exaggerated, but in the case of substances in aqueous solution it seems to be the exception, not the rule, for absorption to take place; and, in the case of ointments, etc., some substances so applied seem to be absorbed and others not." Mercury is absorbed by the skin, but Dr. Thomson's experiments have led him to conclude that the iodide of potassium, which is in very common use by doctors, is not absorbed, and its applications may be abandoned.

Value of Pisciculture. — At the meeting of the British Association, 1862, Mr. Thomas Ashworth, as an illustration of what may be accomplished by attending to the improvement of fisheries, stated that at Galway, Ireland, the salmon-fisheries had, within ten years, been rendered *ten times* more productive. This great improvement has been chiefly owing to the great care taken in preserving the streams during the breeding season, at an expenditure of five hundred pounds, and by introducing young salmon, artificially bred, into streams fitted for them, but from which the fish had before been excluded, owing to impediments preventing access from the sea. These impediments have either been removed or avoided by means of ladders so constructed as to render the passage to and from the sea easy. A striking example was given of a river, in the county of Sligo, Ireland, which had been made productive by means of ladders, which are placed over a fall of forty feet, so that the fish can ascend without difficulty. This river, which a few years ago was entirely barren, now abounds in salmon to such an extent that in the month of July, 1862, as many as one thousand salmon were captured at one locality in one week.

Acclimatization of Sponges. — The French government, encouraged by the success which has attended their efforts in pisciculture, are now attempting to introduce the artificial growth of the finer and more valuable sponges. It is now universally acknowledged that sponges belong to the animal kingdom, and are an aggregate of cellules built up by a gelatinous polyp similar to those which construct madreporæ, porites, and other polypifers. When the sponge is first gathered at the bottom of the sea, it is covered with a black but transparent gelatinous substance, resembling vegetable granulations, among which microscopic white and oviform bodies may be distinguished. These are the larvæ destined to perpetuate the species. When arrived at maturity, they are washed out by the sea-water which incessantly flows through the sponge; they then swim along, by the aid of the vibrating cilia or hairs with which they are provided, until they reach a suitable rock, to which they attach themselves, and there commence a new life. This emigration of the larvæ from the parent sponge occurs about the end of June and beginning of July. The French authorities collected the sponges on the coast of Syria, before the perfection of the larvæ, and, transporting them to proper localities on the coast of France, sunk them, arranged in stone troughs. The success of the experiment cannot, of course, be known at present.

Oyster-Breeding. — M. Coste, who has long paid great attention to pisciculture in all its branches, has recently made a very interesting report to the French Academy "On the Condition of the Artificial Oyster-beds on the West Coast of France." The principal locality selected for the operations is the shore around the Isle of Ré. This island, which is sixteen miles long and four broad, is very favorably situated for the breeding of oysters. The sea-bottom fringing the island was cleared from all impurities; and the seed from oysters having been strewn on the bottom, the work of reproduction went on. Now, it is calculated that seventy-two millions of oysters are produced annually, which, at the rate of 25 or 30 francs per thousand, amounts to two millions of francs per annum. M. Coste states that nothing but very violent currents and a bad sea-bottom prevent the oysters from breeding.

The Smallest of Vertebrate Animals.— Dr. G. C. Wallich has recently contributed to the *Annals of Natural History*, London, a drawing of a lower jaw, the extreme length of which is the 100th of an inch. Assuming the body to have been five times as long as the jaw, he says, "Here we have evidence of the existence of a vertebrate animal measuring only the 20th of an inch, — a size considerably below many of the organisms usually regarded as microscopic. The jaw was recently detected on a shell containing a specimen of muddy deposit dredged up at St. Helena in 1857, in thirty fathoms of water."

Connection between Human and Cattle Disorders. — Prof. Gamgee, in an article on the "Health of Stock," in the *Edinburgh Veterinary Review*, states that he has noticed a remarkable connection between diseases in man and in the lower animals; he believes many of the former may be traced to unwholesome food. The same authority affirms that, on the average, $33\frac{1}{3}$ per cent. of the cows kept in any large town die annually of disease; and he asks, "If our sanitary reformers are alarmed at a mortality of two hundred persons in ten thousand, what will they say to more than sixteen times that mortality amongst our poor cows?"

On the Prevalence and Cause of Goître.—A commission appointed by the French Academy to inquire into and report on the prevalence and causes of goître, have ascertained that, when this disease exists among men and women, it also attacks quadrupeds. The thyroid glands of cows, goats, pigs, horses and mules are found to be affected in those districts where goître is most common. This discovery proves that goître is not induced by diet alone, for many animals that were found to be affected were living on mountain slopes, apart from the dirty villages in the valleys.

The Consanguinity Controversy.—M. Beaudouin communicates to the French Academy an account of his "breeding in and in" with a flock of three hundred sheep without any apparent ill effect; but in this, as in similar cases, the alliances between the two sexes were strictly regulated, and all weak and undesirable animals were excluded. In one case, during a period of twenty-two years, a sheep was born in this flock exactly reproducing the primitive type. M. Beaudouin agrees in the main with M. Sanson, a French naturalist, who disputes *in toto* the proposition that consanguinity tends to deteriorate offspring; but observes that he generalizes too fast when he says that the inconveniences attributed to consanguineous connections have no foundation in observation. "We should add," observes M. Beaudouin, "when such unions take place between selected individuals." M. Gourdon, another French naturalist, however, after reviewing the proceedings of the most celebrated cattle-breeders, contends that Durham oxen, New Leicester pigs, Ditchley sheep, and other successful examples, are, however useful to man, monstrosities, constituted in opposition to all the laws of health, and that connections of consanguinity always produce mischief, although it may be convenient to resort to them for special purposes.

Physiological Effects of Milk.—Mothers have long been aware of the fact that their infants were affected by any changes in the composition of breast-milk, brought about by particular kinds of food, medicine, or other disturbing causes; and a French doctor, M. Labourdette, takes advantage of this circumstance by administering to the mother the physic he wishes to operate upon the child. M. Flourens also has made divers experiments with pigs and other animals. He colored the maternal food with madder, and, in twenty days, found the bones of the little sucklings tinged with that dye. At the meeting of the British Association, in 1860, Mr. Gibb, referring to Vogel's discovery of vibrios in human milk, stated that a child had been brought to him in a state of emaciation. The mother appeared in good health, and her milk was rich in cream and sugar, but it contained numerous vibrios. Subsequent observations confirmed the opinion that milk containing infusoria reduced the children who were suckled upon it to skin and bone.

WOUNDS OF THE BRAIN.

A recent number of the *Comptes Rendus* contains an account of observations and experiments by M. Flourens, showing that wounds of the brain are easily cured. He cites several instances of human beings who have recovered from injuries involving loss of a portion of their brains, and adverts to his own proceedings in introducing leaden balls into the brains of rabbits and dogs. He made a hole in the skull with a trepan, cut through the *dura mater*, and made a slight incision into the brain itself, in which he placed the ball, which gradually sank into the cerebral substance, making a kind of fistula that cicatrized. If the ball was not too big, the whole thickness of the cerebrum or cerebellum might be traversed without being accompanied or followed by any bad symptom or disturbance of functions. He states that, in 1822, he removed one lobe from the brain of various animals, who recovered perfectly, and only lost the sight of the opposite side; and he adds, "but the most remarkable thing was when I removed the whole cerebrum, or both lobes. The animal deprived of his brain survived more than a year, but he had lost all his senses and intelligence, and was reduced to an automaton." In another instance, he took away all the cerebellum, and this creature lived a year. It never regained regularity of movements. It was reduced to the condition of a drunken man.

GIGANTIC CEPHALOPOD.

M. Flourens has recently communicated to the French Academy an account of an enormous cephalopod, seen by Lieut. Bouyer, about forty leagues north of Teneriffe. It appeared to be about ten to fifteen metres in length (from thirty-one to forty-six feet), having a soft, gelatinous body of a reddish color, and shaped like an immense horn, the widest part being about two yards in diameter, and surrounded by very strong arms or tentacles. It was repeatedly shot at, and the balls passed through it without doing much harm. On one occasion, however, a quantity of blood and froth, of a musky odor, flowed from the wound. After being harpooned several times, the body of the creature was surrounded by a rope, and efforts were made to haul it on board. Unfortunately the rope cut the soft flesh, and only the posterior part was secured. The sailors wished to pursue the remainder of the monster in a boat, but Lieut. Bouyer was afraid that its long tentacles, armed with suckers, might enable it to swamp them; and it was, therefore, permitted to escape. He observed that the fishermen of the Canaries often met with similar creatures, exceeding one or even two yards in length; but they were afraid to attack them. M. Milne Edwards recited numerous instances of the appearance of monster cephalopods. Rang had seen one with a body as big as a hogshead; and Steenstrup examined the body of another, which was thrown on the shores of Jutland, and which he denominated *Architeuthis dux*. M. Milne Edwards considered there was reason to believe that these large cephalopods were not all of the same species; and he had no doubt that many kinds, which existed in the depths of the sea, far exceeded the bulk of any known invertebrate animal.

PHYSIOLOGICAL EFFECTS OF TOBACCO-SMOKING.

At the last meeting of the British Association, 1862, Dr. Smith presented an able paper, in which he adduced experiments showing that, while tobacco-smoking causes a large increase in the rate of pulsation of some persons, in others no increase occurs; and hence that there is a diversity in the mode of action of this substance, as there is in the admitted good or evil effects upon the body. The following are the details of one of his experiments. The individual operated on was made to prepare himself by sitting absolutely still until the pulse stood at an average of 74.5 beats a minute. He then commenced to smoke a pipe, and, during the first five minutes of smoking, the effects were comparatively slight; the pulse, however, increased in firmness and fulness, and stood at an average of 78.8 per minute. During the next fourteen minutes the frequency of the pulse was 87, 88, 94, 98, 102, 102, 105, 105, 104, 105, 105, 107, 107, 110, and there was an increased sense of warmth, together with slight perspiration on the brow. Smoking was now stopped, and, during the next minute, the pulse rose to 112; but it then began steadily to decline, till, at the end of half an hour from the commencement of the smoking, it was at 88.91. For more than two hours it remained above the natural average of frequency and force. Dr. Smith assigns the time of 10 P. M. as the proper one for making experiments on the action of tobacco, and adds that no food should be taken for four hours previously. He considers that to literary men, on whom tobacco may be found to produce this kind of stimulant effect, it would be an effective substitute for the wine which they so frequently take to assist them in brain-work which is done late at night; but, when the body is of full habit, it must lead to disturbed sleep, and may produce apoplexy.

ADDITIONAL RESEARCHES ON THE SO-CALLED SPONTANEOUS GENERATION.

Pasteur in his researches on fermentation has brought forward experimental evidence to show that this process depends upon the presence of minute organisms in the fermenting fluid, and that the source of all such organisms is the atmosphere. In support of this opinion he asserts that when a fluid containing organic matter in solution is put into a flask and "boiled two or three minutes," and supplied only with air which has been filtered by passing through a tube heated to redness, and the flask is then hermetically sealed, no fermentation takes place, no organisms are formed, and that the contents remain indefinitely without change. But if the same solution is exposed to the air in its ordinary condition, it becomes filled with various living forms. Out of a large number of experiments prepared in the manner above described, he has not known one to give a different result from that mentioned. He further states that if the neck of the flask is drawn out into a very slender curved tube of several inches in length, the contents boiled, and then allowed to cool without the end of the tube being closed, so that the air enters at the ordinary temperature, and has free access to the interior of the flask, even then no fermentation takes place, and no organisms appear. His explanation of this is, that the air which enters first meets with the hot steam, and the spores or organisms contained in it are killed; while those which enter the tube later move more slowly, and are deposited on the moist walls of it without entering the body of the flask.

To verify these and other researches of M. Pasteur, Prof. Jeffries Wyman, of Cambridge, has recently made a series of experiments to test the question of the formation of minute living organisms in solutions of organic matter which had been boiled and exposed, in hermetically sealed vessels, to air which had passed through iron tubes heated to redness. Thirty-seven experiments were tried, and of these thirty-three were made at the ordinary pressure of the atmosphere, and all but five supplied with air through heated tubes. The solutions were boiled from fifteen minutes to two hours before being sealed, and infusoria appeared in all but four. The first indication of them was a film, which formed on the surface of the solution, sometimes on the second day, generally during the first week, and occasionally not until the nineteenth day from the commencement of the experiment. The solutions consisted of mixtures of sugar and starch, with some albuminous matter, of the juice of beef sometimes filtered, and in other instances containing muscular fibre and vegetable substances. Five experiments were tried in flasks hermetically sealed at the beginning, and then immersed in boiling water, in all of which infusoria were formed.

Four experiments were made with sealed flasks in a Papin's digester, two of them under a pressure of two, and two under five atmospheres. Infusoria were found in one of each.

The organisms consisted of Vibrio, Bacterium, Torula, minute Algæ, also small, round, or oval bodies, moving with vibrating cilia.

In conclusion, Prof. Wyman says: My experiments throw but little light on the immediate source from which the organisms in question have been derived. Those who reject the doctrine of spontaneous generation in any of the forms in which it has been brought forward will ascribe them to spores contained either in the air enclosed in the flask, or in the materials of the solution. In support of this view it may be asserted that it has been proved by the microscopical investigations of Quatrefages, Robin, Pouchet, Pasteur, and others, that the air contains various kinds of organic matter, consisting of minute fragments of dead animals and plants, also the spores of cryptogamous plants, and certain other forms, the appearance of which, as Quatrefages says, suggests that they are eggs. We have made some examinations of our own on this subject, but it would be unnecessary to give the results in detail. We will simply state that we have carefully examined the dust deposited in attics, also that floating in the air collected on plates of glass covered with glycerine, and have found in such dust, in addition to the debris of animal and vegetable tissues, which last were by far in the greatest abundance, the spores of cryptogams, some closely resembling those of confervoid plants, and with them, but much less frequently, what appeared to be the eggs of some of the invertebrate animals, though we were unable to identify them with those of any particular species. We have also found grains of starch in both kinds of dust examined, to the presence of which Pouchet was the first to call attention. When compared with the whole quantity of dust examined, or even with the whole quantity of organic matter, both eggs and spores may be said to be of rare occurrence. We have not in any instance detected dried animalcules which were resuscitated by moisture, and when the dust has been macerated in water none have appeared until several days afterwards, until after a lapse of time when they would ordinarily appear in any organic solution.

Those who advocate the theory of spontaneous generation, on the other hand, will doubtless find, in the experiments here recorded, evidence in support of their views. While they admit that spores and minute eggs are disseminated through the air, they assert that no spores or eggs of any kind have been actually proved by experiment to resist the prolonged action of boiling water. As regards Vibrios, Bacteriums, Spirillums, etc., it has not yet been shown that they have spores; the existence of them is simply inferred from analogy. It is certain that Vibrios are killed by being immersed in water, the temperature of which does not exceed 200° Fah. We have found all motion, except the Brownian, to cease even at 180° Fah. We have also proved by several experiments that the spores of common mould are killed both by being exposed to steam and by passing through the heated tube used in the experiments described in this article. If, on the one hand, it is urged that all organisms, in so far as the early history of them is known, are derived from ova, and, therefore, from analogy, we must ascribe a similar origin to these minute beings whose early history we do not know, it may be urged with equal force, on the other hand, that all ova and spores, in so far as we know anything about them, are destroyed by prolonged boiling; therefore from analogy we are equally bound to infer that Vibrios, Bacteriums, etc., could not have been derived from ova, since these would all have been destroyed by the conditions to which they have been subjected. The argument from analogy is as strong in the one case as in the other. — *Silliman's Journal.*

THE ARTIFICIAL PRODUCTION OF VARIETIES IN INSECTS.

In a paper recently before the Entomological Society of Manchester, Mr. Gregson made the following statements: —

After years of careful study of the habits and food of insects, I determined to ascertain if a change of food would give a change of coloring and marking to species liable to sport, and during the last ten years I have been pursuing my experiments. The results of my experience go to prove that most unquestionably many species, some of them hitherto not often thought liable to vary, may be cultivated into varieties. For instance, *Bucephala*, fed upon sycamore, is much finer and darker than when fed upon any other food, though it is well known that this species is never found upon that tree in its natural state. After enumerating many variations produced by changing the food of the larvæ of insects, the author stated: "What will perhaps interest you most to know, and undoubtedly what I know best, and have oftenest tried and succeeded in producing, is, that *Arctia caja*, fed upon *Petasites vulgare*, or upon the common coltsfoot, will produce darker specimens than when fed upon any other plant; and the chances are that when fed upon this food some of the specimens will prove extraordinarily dark. But there is a singularity in the fact that the darkest specimens so bred rarely open their wings." In opposition to the objections that such variations were the result of disease, it was shown that many of the specimens so varied were of larger and finer growth than the ordinary specimens. In the course of the remarks on this subject, Mr. J. Lubbock suggested the importance of ascertaining the effect of feeding successive generations of the same insect with substances calculated to produce variations, and expressed a hope that some entomologists would extend the observations over a series of years.

DISTRIBUTION OF THE NERVES.

In a paper recently communicated to the Royal Society, Mr. Beale states that he has ascertained that the nerves distributed to the voluntary muscles of the frog do not terminate in free ends, but there is reason for believing that complete nervous circuits exist. In all cases the fibres resulting from the division of the ordinary nerve-fibres are so fine that many cannot be seen with a less magnifying power than 1,000 diameters. And there is evidence of the existence of fibres which could be only demonstrated by employing a much higher magnifying power. It is by these very fine fibres alone and their nuclei that the tissues are influenced. The ordinary nerve-fibres are only the cords which connect this extensive peripheral system. Mr. Beale also finds the same arrangement in the nerves of man and the higher mammalia.

RED CORPUSCLES IN THE BLOOD OF VERTEBRATA.

In a recent communication to the Zoological Society, London, Prof. Gulliver, F. R. S., stated that there have been two parties differing essentially in their conclusions as to the structure of the corpuscles of the blood, both correct as far as they went. The first party, of which Hewson was the representative, insisted that the red corpuscle is a vesicle inclosing a nucleus; the second party, of which Dr. Hodgkin and Mr. Lister were the chiefs, were equally certain that Hewson was wrong, and that the red corpuscle has no nucleus. Prof. Gulliver showed, as the result of his researches from 1839 to '42, that the red corpuscle of mammalia is destitute of any nucleus, while the red corpuscle of oviparous vertebrata, on the other hand, always has a nucleus. Hewson, having drawn his description from the corpuscles of fish or fowls, was quite right so far; and Hodgkin and Lister, having examined only the corpuscles of man, were equally correct in the same restricted sense. Thus Mr. Gulliver's observations not only completely cleared up the long existing discrepancies between former observers, but fairly settled this "vexed question of nucleus," as it had so long been called.

Further, he asserted that the result of his observations clearly was, that the most important, because the most universal and fundamental, difference between the two great divisions of the vertebrate subkingdom, is the presence or absence of this nucleus; so that any one possessing a good microscope could at once plainly see the difference between the red corpuscles of these two divisions of vertebrata. It was also shown that this character is perfectly good from before birth, and throughout life, and in every age and sex, which was more than can be said of any other single diagnostic, whatever may be its importance. Hence Mr. Gulliver proposed to define the two divisions as follows: —

1. Mammalia, animals whose red corpuscles of the blood are destitute of nuclei.

2. Oviparous vertebrata, animals whose red corpuscles of the blood contain nuclei.

He said there was no known exception to the accuracy of these definitions, and that he had proved in 1839 that even the singular oval corpuscles in the blood of *Camelidæ* were in size and structure truly mammalian.

The largest corpuscles among mammalia were shown to be those of the whale, the great ant-eater, and the elephant; and the smallest, as originally described by Mr. Gulliver, those of the musk deer. The largest corpuscles in the vertebrata are those of naked reptiles, and the most regular or least variable those of birds.

Thus the microscope is fairly enlisted into the service of systematic zoology. The subject was followed out in detail throughout the different classes and orders; and so plainly, that an observer might, by remarking the structure of the blood corpuscle, arrive immediately at results which, without the aid of the microscope, would have formerly puzzled the most eminent comparative anatomists. One minutest drop of the blood, for example, of the duck-billed creature, *Ornithorhynchus paradoxus*, would have shown it to belong to the mammalia, and this even in the most immature specimens!

DETERMINING THE ANTIQUITY OF SKELETONS.

Some time ago two human skeletons were found in stone coffins at Vertheuil, in the department of Seine, at Dise. The bones, though brittle, were in a perfect state of preservation, and everything tended to show that these skeletons had been buried many centuries ago. M. Conerbe, a chemist of some note, having obtained the shoulder-blade of one of these relics of past ages, subjected it to analysis, and found that it contained only ten per cent. of organic matter, besides the usual mineral substances of which bones are composed. Now, as fresh bones contain thirty-three per cent. of organic matter, it follows that the bones of the skeletons at Vertheuil had lost twenty-three per cent. of organic substances. From this fact M. Conerbe has endeavored to deduce the age of the bones he has examined. M. Vogelsang, he observes, has found that bones which had been buried eleven hundred years scarcely contained any organic matter; whence M. Conerbe concludes that three per cent. of organic substance disappears every hundred years. Applying this rule to the bones found in the earth at Vertheuil, he fixes the year 1110 as the probable period of the inhumation of these bodies, — a conclusion which tallies with the archæological observations made by M. Leon Drouin, of the Academy of Bordeaux. Hence M. Conerbe's rule is, to divide by three the loss of organic matter ascertained in a bone, the quotient will then represent its age in centuries. This rule, M. Conerbe admits, may be liable to considerable modifications from various circumstances; thus, for instance, bones must be differently affected according as they are exposed to the open air, or inhumed in a damp or dry soil.

THE BIRD OF PARADISE.

During the past year, two male Birds of Paradise have been added to the collections of the Zoological Gardens, London, the first living specimens ever brought to Europe. They were obtained through the efforts of Mr. Alfred Wallace, the well-known English naturalist, who has published an account of the habits and *habitat* of these birds.

The Bird of Paradise species is wholly confined to the New Guinea and Aru Islands of the South Pacific, and to a limited space, moreover, of those countries. Aru consists of a very large central island, and some hundreds of smaller ones scattered around it at various distances, many being of large size, and covered with dense and lofty forests; yet on not one of these is the Paradisea ever found (although many of them are much nearer New Guinea); but it is limited to the large island, and even to its central portions, never appearing upon the sea-coast. In the central forests of Aru it is, however, very abundant, and fills the woods with a loud, harsh, oft-repeated cry of *wok*, *wok*, *wok*. Their plumage is in full perfection in May and June, which is the season of pairing. All are then in a state of excitement and incessant activity, and the males assemble together to exercise, dress, and display their magnificent plumage. For this purpose they prefer certain lofty, large-leaved forest-trees (which at this time have no fruit), and on these, early in the morning, from ten to twenty full-plumaged birds assemble, as the natives express it, "to play and dance." They open their wings, stretch out their necks, shake their bodies, and keep the long, golden plumes opened and vibrating, constantly changing their positions, flying across and across each other from branch to branch, and appearing proud of their activity and beauty. The long, downy, golden feathers are, however, displayed in a manner which has, says Mr. Wallace, been hitherto quite unknown, but in which alone the bird can be seen to full advantage, and claim our admiration as the most beautiful of all the beautiful winged forms which adorn the earth. Instead of hanging down on each side of the bird, and being almost confounded with the tail (as I believe always hitherto represented, and as they are, in fact, carried during repose and flight), they are erected *vertically* over the back from under and behind the wing, and then opened and spread out in a fan-like mass, completely overshadowing the whole bird. The effect of this is inexpressibly beautiful. The long, ungainly legs are no longer a deformity, as the bird crouches upon them, the dark brown body and wings form but a central support to the splendor above, from which more brilliant colors would distract our attention; while the pale yellow head, swelling throat of rich metallic green, and bright golden eye, give vivacity and life to the whole figure. Above, rise the intensely-shining, orange-colored plumes, richly marked with a stripe of deep red, and opening out with the most perfect regularity into broad, waving feathers of airy down; every filament which terminates them distinct, yet waving and curving, and closing upon each other with the vibratory motion the bird gives them; while the two immensely long filaments of the tail hang in graceful curves below.

The natives procure the Bird of Paradise by building a small inartificial-looking hut in the tree while the birds are absent, and shooting them with arrows when a sufficient number have arrived, by concealing themselves in the hut.

"Nature," says Mr. Wallace, "seems to have taken every precaution that these, her choicest treasures, may not lose value by being too easily obtained. First we find an open, harborless, inhospitable coast, exposed to the full swell of the Pacific Ocean; next a rugged and mountainous country, covered with dense forests, offering, in its swamps, precipices, and serrated ridges, an almost impassable barrier to the central regions; and, lastly, a race of the most savage and ruthless character in the very lowest stage of civilization. In such a country and among such a people are found these wonderful productions of nature. In those trackless wilds do they display that exquisite beauty and that marvellous development of plumage, calculated to excite admiration and astonishment among the most civilized and most intellectual races of man."

POISONS NOT ALWAYS POISONS.

Mr. J. Attfield lately read a paper before the London Pharmaceutical Society, in which he stated that he had discovered that some of the most active extracts in the pharmacopœia — extract of colocynth and extract of nux vomica, for example — supported colonies of lively little animals, greatly resembling cheese-mites. They proved, in fact, to be a hitherto unknown species of *acari*. Other irritating substances have been known to support similar animals. Ginger has been found to be infested with them; but in this and similar cases it was supposed that they lived on the starchy matter, and rejected the active principle. But it was impossible that they could eat extract of nux vomica without eating strychnia. It might be, however, that the strychnia was not assimilated. Mr. Attfield, therefore, collected some acarine excrement (the excrement floats on, while extract of nux vomica sinks in water), tested it for strychnia, and only discovered a trace of that body, which he believed to have been dissolved off from the extract by the moist excrement. But, to prove that these animals could live on food that was to other animals a deadly poison, Mr. Attfield took several of them from the extract and put some into microscopic cells containing powdered strychnia, and others into empty cells. In two days those in the empty cells were starved to death, while those supplied with strychnia were as lively as ever. Some of the animals from extract of colocynth lived just as well on strychnia, and, indeed, seemed equally well, whether their food was colocynth, strychnia, morphia, or cheese. As "poison-mites" relished cheese, Mr. Attfield thought cheese-mites might relish poison. He therefore took some from cheese and put them on powdered strychnia, but the experiment was fatal to them; they all died. Others, however, thrived on cheese, adulterated with twenty per cent. of strychnia. Mr. Attfield infers that acari digest strychnia, which becomes oxidized in their blood, and its chief elements removed in the respiratory process. The fact of an animal's becoming habituated to a poison is not new. Men eat arsenic, opium, and tobacco, until their daily dose is sufficient to kill from two to ten of their species. Sheep have been known to eat poisonous plants until their mutton produced serious effects on those who ate it. Hedgehogs will eat anything, and toads are indifferent to prussic acid. Drawings of three acari discovered were exhibited, and Mr. Attfield said that Mr. Busk had decided that those found on the extracts of colocynth and taraxacum belonged to the same genus, but were of different species, and that those existing on nux vomica were generally different from others.

Mr. Deane noticed that the acari figured greatly resembled some found a few years ago under very peculiar circumstances. At a village near Colchester, the name of which we did not catch, a church was rebuilt, the floor being lowered to within a few inches of some coffins that had lain under ground for two or three centuries. Soon after the new church was opened the pews were found to be infested with mites, so numerous in some places as nearly to hide the fittings. It turned out to be a new species of acarus, and received the name of *Acarus ecclesiasticus*. The parishioners were greatly alarmed at the visitation, and regarded it as a judgment of the Almighty for desecrating the graves of their forefathers. Mr. Deane added that the animal was very like that claimed to have been made by galvanism, some years ago, by the late Mr. Cross.

THE SNOUT OF THE HOG.

At a recent meeting of the Boston Society of Natural History, Mr. Wilder described the muscles which move the snout of the hog. The elevator has a very long tendon, and its muscular attachment is very far back, protected by a long ridge, and safe from all ordinary accidents; the depressor, on the contrary, is very short, and attached very near the terminal cartilage, both muscles of the important organ being thus protected from injury. He remarked that while we consider the long snout of the hog, compared with that of common animals, as a sign of what we know to be his beastly nature, yet the same organ, still further prolonged into the trunk of the elephant, changes its function with the nature of the animal so as to be capable of executing very various and delicate motions. So that it is not always safe to take a single organ as an index of the nature of the possessor.

ASTRONOMY AND METEOROLOGY.

NEW PLANETS.

Four additional asteroidal planets have been discovered during the past year, making the whole number now recognized seventy-six.

The seventy-second asteroid, though optically discovered in 1861, was first recognized as an individual planet in January, 1862. Its detection is due to Mr. Safford, of Cambridge, Mass., who had been engaged contemporaneously with Dr. Peters, of the Hamilton College Observatory, New York, in observing the planet Maia, discovered in the preceding April by Mr. Tuttle (see *Annual of Scientific Discovery*, 1862, page 368). To this planet the name *Feronia* has been given.

The seventy-third asteroid was discovered April 8, 1862, by Mr. Tuttle, of the Cambridge (Mass.) Observatory, and has received the name *Clytie*, — a name borne by a daughter of Oceanus and Tethys, in the ancient Greek mythology.

The seventy-fourth asteroid was discovered August 29, by M. Temple, at Marseilles, France, and has received the name of *Galatea*. This planet is supposed to have been discovered by Mr. Parkhurst, of New York, three weeks later.

The seventy-fifth asteroid was discovered September 22, by Dr. Peters, of Hamilton College, New York.

The seventy-sixth asteriod was discovered by M. D'Arrest, at Copenhagen, and has received the name of *Freya*, the Venus of Scandinavian mythology.

Asteroid fifty-nine, discovered by M. Chacornac, at Paris, in 1860, which has not heretofore been definitely named, has received during the past year the name *Olympia*.

The asteroid Daphne, which has persistently escaped the researches of astronomers since its discovery in 1856, and which seemed hopelessly lost, is believed to have been rediscovered, and its elements determined, during the past year, by M. Luther, of Bilk (see *Annual of Scientific Discovery*, 1862, pp. 369, 370). Some changes have been recently made in the heretofore received nomenclature of the asteroids. Pseudo-Daphne, the asteroid mistaken in 1857 for Daphne, has received the name Melete. Asteroid fifty-nine has been designated as Olympia, and also as Elpis; sixty as Danäe; sixty-one as Echo; sixty-two as Erato; sixty-three as Ausonia; sixty-four as Angelina; and sixty-five as Cybele.

The asteroid nearest the sun is (seventy-two) Feronia; the one most remote is (sixty-five) Cybele. The orbit of Feronia is nearer to Mars than to Cybele. The asteroid whose orbit has the least eccentricity is Concordia, being 0.04; and that which has the greatest is Polymnia, being 0.337; which is greater than that of any other known planet. The asteroid whose orbit is least inclined to the ecliptic is Massalia, — inclination 0° 41′; that whose orbit is most inclined is Pallas, whose inclination is 34° 42′.

The method adopted by the German astronomers for determining the magnitude of the asteroids is, by comparing their reflecting capacities with that of other celestial bodies whose magnitudes are known. This process gives to Maia (sixty-six), discovered by Mr. Tuttle, of the Cambridge (Mass.) Observatory, a diameter of only 19.1 English miles, if its reflecting capacity is equal to that of Saturn or Uranus, or 65.2 miles, if it reflects only the same proportion of incident light that the moon does. This circumstance also affords most striking testimony to the excellence of the telescope that it is capable of presenting to the eye and subjecting to measurement an object of such minuteness.

COMETS OF 1862.

Four new comets have been discovered within the year, and two of them were marked by features that give them considerable distinction among their fellows. Among the distinctions which the first comet of the year enjoys are the geographical and historical circumstances of its earliest discovery at Athens by M. Schmidt, and of its being the first physical discovery in the celestial spaces made there in modern times. After an absence of two thousand years astronomy returns to the land of Hellas, where its first theories were conceived and its foundations laid by such illustrious cultivators as Thales, Pythagoras, and Hipparchus. This comet was first detected on the night of the 2d of July, in Cassiopeia; and it had, at that time, passed its perihelion ten days. It was visible to the naked eye for a short time as a nebulosity, having the lustre of a star of the fourth magnitude. It was remarkable for its great geocentric angular velocity, and its proximity to our globe, but few comets on record having surpassed it in these circumstances. On the 4th of July it was only nine millions of miles distant from the earth, and was then moving at the rate of twenty-four degrees per diem, reduced to the arc of a great circle.

The second comet of 1862 was remarkable both for its brilliancy and for its physical features. In these particulars it was surpassed only by the great comets of Donati and that of 1861. It was first discovered by Mr. Swift, an amateur astronomer at Marathon, Cortland County, New York, on the evening of July 15th, and was subsequently observed by Mr. Tuttle of the Cambridge Observatory, and Mr. Simons of the Dudley Observatory, Albany; on the 18th, three days later. The nucleus of this comet was estimated at about one hundred thousand miles diameter; and the tail must have been not far from eighteen millions of miles in length, which is something longer than that of the great comet of 1861, which stretched so far across the heavens. This comet never came nearer the earth than thirty-five millions of miles, which is a distance nearly three times as great as that which the last-named comet had when nearest the earth. The most striking phenomenon noticed in this comet was the evolution from the head or nucleus of two sheaf-like streams of luminous matter in opposite directions, indicating two fixed centres of eruption. M. Secchi, the distinguished Roman astronomer, in describing this appearance, says: — "The tail was simple, until the two reversed jets, or *aigrettes*, were well developed, so that no doubt could remain that it was really these nebulosities which, in reversing themselves, produced the tail." The periodicity of the jets at first suggested a rotation of the comet about an axis, but the idea was not confirmed by observation. The light of the nucleus and of the *aigrettes* was only polarized once, and then very feebly. The nebulosities, on the contrary, were always strongly polarized. These facts indicate a different molecular condition, and M. Secchi suggests that the nucleus and the aigrettes may have been formed of vapor analogous to our clouds, which do not polarize, while the nebulosities had passed into a state of gas which polarizes like our atmosphere. He adds, "We might also admit that the nucleus and the aigrettes were incandescent, but the supposition is a little difficult. After the perihelion passage there appeared vestiges of paraboloid surfaces enveloping the sheaves of light, as if the matter was being deposited in layers as the comet cooled."

M. Chacornac, of the Paris Observatory, who observed this comet carefully, thus describes its phenomena: — "The nucleus of the comet emits, in the direction of the sun, a vaporous jet, from which there appear to proceed particles of cometary matter, in the same way as a jet of steam escapes from a machine. This preserves, during a certain time, a rectilinear form, which seems to indicate a considerable force of projection emanating from the nucleus. Soon after, it curves slightly, and presents the appearance of an arched cone, exhibiting a good deal of analogy to a cornucopia, such as they are generally represented. At this moment the gaseous particles accumulate at the extremity of the jet nearest the sun in the form of rounded clouds, and this appearance seems to indicate that at this distance from the nucleus the force of projection is subdued by some resistance opposed to it. Some hours later this luminous jet assumes a diffuse aspect, and shows that the emission from the nucleus has ceased to continue in this direction. At the moment that it begins to change, and in an angle inclined thirty degrees towards the east, one perceives the first traces of a new ray, whose development presents the same phases as the preceding one. Sixteen hours later one observes a new ray in the direction of the first one seen the night before, and this last, continuing to change in this interval of time, appears dispersed in the hemispherical envelope, like a fog, hardly preserving traces of its original form and direction. In these successive transformations the new ray presents afterwards the same appearance as the one parallel to the radius vector."

Since the disappearance of this comet, Mr. Safford, of Cambridge, and other (European) observers have determined, from a discussion of its elements, that this body is a member of the solar system, moving in an elliptical orbit, with a period of one hundred and thirty-one and a half years. The ellipse has considerable inclination to the plane of the ecliptic, and intersects it in the two zodiacal constellations, Leo and Capricorn. It is extremely elongated, the outermost part lying away in space, on the southerly side of the ecliptic, nearly as far beyond the orbit of the planet Neptune as Neptune himself is from the sun. When in perihelion, or nearest the solar orb, the comet is just within the orbit of the earth. It passed through its perihelion August 22d, 1862, and will not return there again before the year A. D. 1994. This comet, although periodical, has never before been recognized, which is partly due to the unfavorable position for observation which it had at former approaches to the sun.

Two other comets were discovered in November and December, 1862, by Dr. Bruhns, of the Observatory of Leipsic, but little has yet been made known concerning them.

Encke's Comet. — This little periodical comet again made its appearance after a lapse of four years at the close of the year 1861, quite near its predicted place, and, according to Mr. Bond, exhibited the same physical phenomena as it has presented on former occasions. Mr. Bond says: — At first it was quite destitute of any central condensation — more so in fact than is common with even the faintest telescopic comets. This is its usual aspect when far distant from the sun. It soon acquired greater consistency, and even exhibited an almost sparkling nucleus. It was for some time visible to the naked eye, and showed a respectable tail one degree in length.

Its most interesting peculiarity was a very decided disposition of its nebulosity on the side towards the sun, constituting a faint tail, as it were, opposed to the normal direction. This was formed a long time before the true tail made its appearance. It is by no means a new feature, as it is mentioned in its preceding apparitions by Struve, Schwabe, Wichman, and others. In 1848, and again in 1852, it was particularly evident. The fact of its repetition in so many instances gives a kind of individuality to this comet, distinguishing it from most bodies of its class, and is interesting from its associations with its otherwise very remarkable character.

Did the Earth pass through the Tail of the Great Comet of 1861 ? — A review of all the phenomena of the great comet of June, 1861, has led astronomers very generally to the belief that on the 3d of June our planet actually passed through, or came in contact with, the extremity of its tail, with no other effect than an auroral glare, noticed by various observers. Admitting the probability of this conclusion, it cannot be thought surprising that there should have been at the time so little sensible indication of its presence. Whatever may be the nature of that wholly unknown material, there can be no question of its extreme and almost inconceivable attenuation. The air we breathe may be as dense in comparison with it as water or even earth in comparison with air. The minutest stars have been frequently seen through thousands of miles of it, and it even ceases to be amenable to the all-controlling force of gravitation ; so that Newton considered that the tail of a great comet might be compressed into the bulk of a single cubic inch before it would equal the density of our atmosphere, and Sir J. Herschel supposes that it may not contain more than a few pounds or even ounces of matter. It would, therefore, be highly improbable that there should be a sufficient quantity of it in the immediate vicinity of any one place of obse... -tion to render its presence manifest. Distance alone, by bringing its particles into more apparent concentration, could give it density enough to become perceptible, just as the same cause converts the unsubstantial and semi-transparent mist into the massive and ponderous-looking cloud. It was a more significant fact, and one which may not be generally known, that no electric or magnetic effect whatever was perceptible during its passage; for such influences have been strongly suspected in cometary phenomena, and might act independently of any material admixture.

OBSERVATIONS ON MARS AND THE MOON.

In 1858, M. Secchi found the appearance of Mars differ considerably from the drawings of Maedler, and other astronomers. Now the planet has returned to its former aspect, and instead of exhibiting large, complicated solar spots, showed them to be reduced to a small circle, as in Maedler. The great spots had given place to rose-colored surfaces, traversed by blue canals, as represented in Secchi's picture of 1858. From these changes he thinks no doubt can remain that the polar spots consist of snow or condensed clouds, which the summer heat of the planet melts. The red surface he regards as land, and the blue canals as water. — *Comptes Rendus.*

Observations on the Moon. — Mr. Lassell, the well-known English astronomer, who has recently established a magnificent four-foot reflecting telescope at Malta, states, in a letter to the President of the Royal Society, that he observes the details of the moon with a sharpness and distinctness which he had never seen before; and says that if a carpet the size of Lincoln's Inn Fields were laid upon its surface, he could tell whether it was round or square. He adds, "I see nothing more than a repetition of the same volcanic texture, — the same cold, crude, silent, and desolate character which smaller telescopes usually exhibit."

NEW THEORY OF COMETS.

In an article contributed to *Silliman's Journal*, Mr. Benjamin Marsh attributes the peculiar character of cometary matter to the extreme and violent changes which it undergoes in its rotation round the sun. Halley's comet, for example, at one time approaches the sun to within fifty-six millions of miles, and then recedes to the enormous distance of thirty-three hundred and seventy millions of miles. At the time of its perihelion, or least distance, it passes through one heliocentric degree of its orbit in 15.7 hours, and receives in a given time three thousand six hundred times as much heat as when it reaches its aphelion, or greatest distance, in which position its motion is so slow that six and one-half years are required for its passage through one heliocentric degree. Thus it will be seen that comets with eccentric orbits are subject to violent changes of temperature and velocity which do not affect planets whose orbits approximate more closely to the circular form, and from this circumstance a greater electrical disturbance and excitation may possibly be produced. Mr. Marsh gives a table of remarkable comets, showing that those which have exhibited the greatest splendor have been distinguished by extreme eccentricity, while comets of small eccentricity have been inconspicuous. From this law it follows that brilliant comets have long periods; and he tells us that, with the exception of Halley's comet, which performs its journey in seventy-six years, no other first-class comet has a shorter period than one measured by centuries. Mr. Marsh likens the tails of comets to auroral streamers, and considers that their envelopes resemble the electrical discharges in Mr. Gassiot's vacuum tubes, the luminous character being derived from the solid particles which the electrical current transports from the nucleus, just as similar particles are carried off from the electrodes in a voltaic discharge.

PROTUBERANCES ON THE SUN.

Mr. Balfour Stewart, F. R. S., in an article in the *Philosophical Magazine*, suggests that the mysterious red protuberances observed on the sun's limit at the moment of total obscuration bear some analogy to the terrestrial phenomena of the aurora borealis, and he adduces several arguments in favor of his supposition. First, he contends that the terrestrial aurora is the induced effect in the upper regions of small but rapid changes occurring in the intensity of the earth's magnetism, which itself, according to Gen. Sabine, is influenced by the sun. These changes are coincident with auroras, and if in a measure resulting from the sun may occasion similar effects in the atmosphere of that luminary. This idea being communicated to Gen. Sabine, the latter further developed it by remarking that a solar aurora might possibly call forth simultaneous corresponding auroras in all the planets, proportioned to their strength. Mr. B. Stewart concludes his paper with an enumeration of the points of likeness existing between the protuberances, considered as red flames, and terrestrial auroras. These are: 1. Their extreme height; 2. Their great actinic effect; 3. Their red or violet color; 4. Their unpolarized light; and, 5. The curved appearance of some of the flames, similar in some respects to the auroral arch.

SOME PECULIAR FEATURES OF THE SUN'S SURFACE.

At the meeting of the British Association, 1862, Mr. Nasmyth gave a sketch of the character of the sun's surface as at present known. He described the spots as gaps or holes, more or less extensive, in the luminous surface or photosphere of the sun. These exposed the totally dark bottom or nucleus of the sun. Over this appears the mist surface,—a thin, gauze-like veil spread over it. Then came the penumbral stratum, and, over all, the luminous stratum, which he had had the good fortune to discover was composed of a multitude of very elongated, lenticular-shaped, or, to use a familiar illustration, willow-leaf-shaped masses, crowded over the photosphere, and crossing one another in every possible direction. The author had prepared and exhibited a diagram, pasting such elongated slips of white paper over a sheet of black card, crossing one another in every possible direction in such multitudes as to hide the dark nucleus everywhere, except at the spots. These elongated, lens-shaped objects he found to be in constant motion relatively to one another. They sometimes approached, sometimes receded, and sometimes they assumed a new angular position, by one end either maintaining a fixed distance or approaching its neighbor, while at the other end they retired from each other. These objects, some of which were as large in superficial area as all Europe, and some even as the surface of the whole earth, were found to shoot in thin streams across the spots, bringing them over in well-defined streams or comparative lines, as exhibited on the diagram; sometimes by crowding in on the edges of the spot they closed it in, and frequently at length thus obliterated it. These objects were of various dimensions, but in length generally were from ninety to one hundred times as long as their breadth at the middle or widest part.

THE ZODIACAL LIGHT.

In a paper on the above subject, read before the British Association, 1862, by Prof. Challis, the phenomena of the zodiacal light, as gathered from observations made both in northern and in southern latitudes, were stated to be as follows: As seen in north latitudes, it appears in the west after the departure of twilight, as a very faint light, stretching along the ecliptic, about ten degrees broad at its base in the horizon, and coming to an apex at an altitude of forty to fifty degrees. It is most perceptible in the west in the months of February and March, at which time its apex is near the Pleiades. Similar appearances are presented in the morning before sunrise in the east, in the months of August and September. The light seen in the autumn lies in the *same* direction from the sun as that seen in the spring. In the southern hemisphere, the appearances are strictly analogous; but the times and positions of maximum visibility are the evenings in autumn in the west and the mornings in spring in the east. The portion best seen in the southern hemisphere lies in the *opposite* direction from the sun to that which is best seen in the northern hemisphere. The portion seen and the degree of visibility depend on the inclination to the horizon of the part of the ecliptic along which the light stretches. The greater the inclination, the better it is seen. At the December solstice, opposite portions have been seen in the northern hemisphere, one in the morning, and the other in the evening; and in the southern hemisphere opposite portions have been similarly seen at the June solstice. At these seasons, the ecliptic is inclined at large and equal angles to the horizon, at equal intervals before sunrise and after sunset.

Professor Challis attributed the zodiacal light to an effect produced on the luminiferous ether by the sun's rotation round its axis, combined with a motion of translation of the solar system through space. Shooting stars were similarly attributed to the effect on the ether produced by the motion of the earth in a cycloidal curve, resulting from the same motion of translation and the proper motion of the earth in its orbit.

COMPANION TO SIRIUS.

In 1861, Mr. Safford, of the Cambridge Observatory, announced (see *Annual of Scientific Discovery*, 1862, p. 388) that the irregularities observed in the motion of the bright star Sirius could be legitimately accounted for on the hypothesis of its revolution around an invisible companion of no inconsiderable magnitude. This announcement had hardly found its way into print, when Mr. Alvan Clark, of Cambridge, Massachusetts, through the agency of a new achromatic telescope (recently constructed by him), having an object-glass of eighteen and a half inches in diameter, and an illuminating power exceeding by more than one-half any other achromatic in existence, discovered an object near Sirius, hitherto unknown to astronomers; a discovery since verified by many astronomers in this country and in Europe. It is somewhat difficult to assign a reason why the existence of this body has not been made known before, as it is readily visible through powerful telescopes, even a few minutes after sunset. It, however, remains to be seen whether it will have to be the hitherto invisible body disturbing the motions of Sirius. Mr. G. P. Bond, in a communication to *Silliman's Journal*, says of it: — It will require one, or at the most two years to prove the physical connection of the two stars as a binary system. For the present we know only that the *direction* of the companion from the primary accords perfectly with theory. Its faintness would lead us to attribute to it a much smaller mass than would suffice to account for the motion of Sirius, unless we suppose it to be an opaque body or only feebly self-luminous.

DISAPPEARANCE OF NEBULÆ.

One of the most mysterious and unlooked-for of recent phenomena in the heavens is the discovery of a change of lustre, and even disappearance of certain nebulæ. The nature of these phenomena is thus set forth in a recent statement published by Mr. Hind, the well-known English astronomer. Towards the close of 1861, it was announced by Prof. d'Arrest, of Copenhagen, that a nebula in the constellation *Taurus*, which was discovered on the 11th of October, 1852, had totally vanished from its place in the heavens. That one of these objects, which the giant telescopes of the present day had taught us to regard as assemblages of stars in myriads at immense distances from the earth, should suddenly fade away, so as to be quite imperceptible in powerful instruments, must, I think, have been deemed a very improbable occurrence, even by many who are well acquainted with the care and experience of the observer by whom the statement was made. Since the date of M. d'Arrest's statement, however, M. LeVerrier has obtained so strong a confirmation of its accuracy that there is no longer room for supposing it to have originated in one of those errors of observation which every practical astronomer knows will creep into his work in spite of all his precautions.

The nebula in question was situated in right ascension 4 hours 13 minutes 54.6 seconds, and north declination 19° 11′ 37,″ for the beginning of 1862. It was, therefore, about a degree and a half from the star *Epsilon* in *Taurus*, in the group commonly known as "the Hyades." Its diameter was about one minute of an arc, with a condensation of light in the centre; or its appearance was that of a distant globular cluster, when viewed in telescopes of insufficient power to resolve it into stars. From 1852 to 1856 a star of the tenth magnitude almost touched the edge of the nebula at its north-following edge; it was at first remarked on the night the nebula was detected, having escaped notice on many occasions when its position had been under examination with the same telescope and powers. Hence I was induced to hint at its probable variability in a note upon the nebula, published in No. 838 of the *Astronomische Nachrichten*. The suspicion is fully confirmed; the star has diminished to the twelfth magnitude, either simultaneously with, or soon after, the apparent extinction of the nebula.

M. LeVerrier states that on the night of January 26th, 1862, the sky being very clear at intervals, the Paris equatorial, which has an object-glass twelve French inches in diameter, was directed to the place of the nebula, but, notwithstanding stars of an extremely faint class were visible in its immediate neighborhood, not the slightest trace of it could be perceived. The star which d'Arrest and Mr. Hind had repeatedly noted, of the tenth magnitude, and almost touching the nebula, had dwindled down to the twelfth; so that telescopes which would have shown it well between 1852 and 1856 would not at present afford a glimpse of it. From the fact that M. Chacornac saw the nebula in forming a chart of the stars in that region in 1854, and did not remark it while reconstructing the same in 1858 with a much more powerful instrument, there is reason to infer that the disappearance took place in 1856 or the following year.

How the variability of the nebula and a star closely adjacent is to be explained, it is not easy to say in the actual state of our knowledge of the constitution of the sidereal universe. A dense but invisible body of immense extent, interposing between the earth and them, might produce effects which would accord with those observed; yet it appears more natural to conclude that there is some intimate connection between the star and the nebula, upon which alternations of visibility and invisibility of the latter may depend. If it be allowable to suppose that a nebula can shine by light reflected from a star, then the waning of the latter might account for apparent extinction of the former; but in this case it is hardly possible to conceive that the nebula can have a stellar constitution. It is at least curious that several variable stars have been detected in the region of the great nebula, in *Orion;* that in 1860 a star suddenly shone out in the middle of the well-known nebula *Messier* 80 (about half-way between *Antares* and *Beta* in *Scorpio*), which vanished in a few days, and that, as first remarked by Sir John Herschel, all the temporary stars, without exception, have been situated in or near to the borders of the *Milky-Way* — the star cluster or ring to which our system of sun and planets belongs. In the latter class are included the memorable star of B. C. 134, which led Hipparchus to form his catalogue of stars, and those which blazed forth in 1572 and 1604, in the times of Tycho Brahe and Kepler.

Prof. Secchi, the well-known Roman astronomer, also informs Mr. Hind that he has been unable to detect any traces of the nebula with the powerful telescope at his command, and favored by the clear sky of his locality.

M. d'Arrest, since the above statement of Mr. Hind, also announces that he has detected a similar change in a nebula discovered by Mr. Tuttle in February, 1859, and one discovered by Mr. Temple in October of the same year. He regards a change of lustre in these three nebulæ as clearly established; and mentions, as a curious fact, that they are all situated in the same celestial region, and in the vicinity of the Pleiades.

ANNULAR NEBULA.

In a letter read before the French Academy, October, 1862, Mr. Lassell, the English astronomer, who has located his observatory at Malta, describes a new and marvellous nebula, situated in the 20th hour at 101 degrees 56 minutes from the pole. A 1480 magnifying power reveals inside the nebula an elliptical ring, perfectly well defined, and without any apparent connection with the surrounding nebulous matter. This last, says Mr. Lassell, is like a thin veil of vapor, and not confounded with the margin of the ring, whose splendor it diminishes very little. The nebulous envelope, a little more removed from the extremity of the conjugate axis than from the extremity of the transverse axis, is in reality very fully prolonged, and it is difficult to follow its traces amongst the stars that precede and follow it. There is a star near its northern border in the prolongation of its conjugate axis. The breadth or thickness of the ring differs from that of Saturn in being nearly uniform throughout. It appears, therefore, that if its form is really elliptical, we must see it in a direction almost perpendicular to its plane; while, if it is actually circular, it is presented to us a little foreshortened. A section passing through any portion of the space between its inner and outer sides would be circular. In other words, it is like a cylinder bent round till both ends meet.

At first I was inclined to refer it to the same class as the annular nebula of Lyra, chiefly on account of its central star, which was, however, of greater brilliance; and, besides this, the resemblance is incomplete, for the ring is much more symmetrical, and better defined at its edges. It suggests the idea of a compact assemblage of brilliant stars, like the milky-way. The brightness of the ring is not strictly uniform, the south preceding position being slightly more luminous. Mr. Lassell proceeds to remark that observations on this nebula are extremely difficult, and that it was only when the fine climate of Malta afforded him a night of unusual clearness, and permitted the employment of a power of 1,480, that its details were revealed. He concludes thus:—"I confess I was strongly impressed with the appearance of this marvel, situated, without doubt, at the extreme limit of the regions accessible to our investigation, and affording reason to believe that the heavens that are invisible to us are peopled with systems more splendid than any which we are permitted to contemplate."

SATURNIAN PHENOMENA.

One of the most interesting astronomical phenomena of the past year has been the temporary disappearance of the ring of Saturn, that is, from May to August. The cause of this phenomenon is generally understood; but it may be well to refer to it in this place on account of some curious details connected with it. The position of this great plane (or rather assemblage of planes, *the only flat surface that we know of in the universe*) does not coincide with the plane of the orbit of Saturn; if it did, it would always present its edge to the sun, and neither of its sides would receive more than a horizontal illumination. Nor does it lie in the plane of the orbit of the earth, which is inclined to that of Saturn, and, excepting in the two points where it crosses his orbit, has no reference to it whatever. But it is so placed as to make a considerable angle (26° 49′ 17″) with the orbit of Saturn, and while it is carried round the sun with the planet, it remains always parallel to itself, since a fresh direction could only be the result of a fresh force impressed upon it from without; and no such force exists. Hence, in the course of one revolution of Saturn, or twenty-nine and a half of our years, it turns first one and then the other side to the sun; and in passing from the one to the other position, presents to him for a short time its edge, in which situation, from its extreme thinness, estimated by Mr. Bond at less than forty miles, it will not reflect light enough to be visible at the distance of the earth, without the greatest difficulty. But this is not the sole condition of the phenomenon, which depends not only on the position of the sun, but of the earth also; as the earth is but seldom exactly in the line between the sun and Saturn, it may so happen that the edge of the ring, when not presented to the sun, may be turned towards ourselves, and then again its thinness will withdraw it from sight. And there is a third case of partial disappearance when the sun and earth are on opposite sides of the ring, and we look on the darkened side. This latter conjuncture happened during the past year.

Mr. Dawes, the English astronomer, thus describes the appearance of Saturn on the 17th of May, 1862:—With a power of six hundred and twenty on an eight and a half inch object-glass, the features of Saturn came out with beautiful distinctness, and the edge of the disc was sharply defined. The arms of the ring were scarcely at all visible, a very faint gleam of coppery light, at moments of finest vision, being the only indication of its existence beyond the disc of the planet. On the disc the projected ring appeared as a very dark line a little north of the equator, and of uniform breadth. But I was much surprised that, under the finest definition with this high power, I could discern no trace of the shadow of the ring. I expected to see it, if the atmospheric circumstances were sufficiently good, as an exceedingly fine black line stretched across the disc about a quarter of a second to the south of the inner edge of the projected ring; and that the shadow of the satellite would travel almost centrally on the black line, a great part of it, however, falling on the southern portion of the ring. But no such thing was to be found. Nothing, I imagine, can more fully prove the almost inconceivable thinness of the ring than the absence of all perceptible shadow. Had it even the least thickness which has ever been ascribed to it, namely, forty miles, by Mr. P. Bond, of the Harvard Observatory (United States), it would be sufficient to produce a total eclipse of the sun on Saturn's equator, as it would subtend an angle more than double that subtended by the disc of the sun as seen from Saturn.

A very curious phenomenon connected with the disappearance of Saturn's ring is a knotty aspect which it often assumes when reduced to extreme thinness. This, as Olbers long ago pointed out, is the mere effect of perspective foreshortening upon unequal degrees of illumination. The ring consists of concentric zones of different degrees of brightness; the ends of these, when viewed very obliquely, will, in proportion to their brilliancy, appear to project like knots or beads upon the minute line formed by the fainter parts of the ring. So far the explanation is satisfactory; and though these knots have been seen even when the dark side of the ring has been turned towards us, this has been accounted for by Bond as the reflection of the sun's light from the edges of the rings,which we might see through their interstices from beneath. But when we find the number of knots unequal on the two sides of the planet, as has often been noticed, and especially by Schröter and Harding, in 1803, or when the two ansæ are unlike in length, or breadth, or continuity, or in the epoch of vanishing or reappearing, as in 1671, 1714, 1744, 1774, 1789, 1803, 1833, and 1848, we are obliged to infer some physical irregularity: either the rings do not all lie in the same plane, or they have, as Schröter thought, mountainous prominences of great magnitude; the latter idea, singular as it may appear, is countenanced by the notched form of the shadow upon the ball which was several times seen by him, and since by Schwabe (probably) in 1848, by Lassell in 1849 and 1861, and by De La Rue also last spring. If this, however, is the cause, the rotation assigned to the ring by Sir W. Herschel from a movable protuberance in 1789 must be abandoned, at least upon that ground, since his observation, never since confirmed, is contravened by the stationary character of these projections. Rotation would not be incompatible with the idea of different planes; but if we may credit the statements of a far inferior observer, De-Vico, who saw a lucid point adhering to the *opened* ring in 1840 and 1842, it can no longer be maintained upon any ground, and the ring must be considered fixed. How to account for its stable equilibrium and permanency would then be a difficulty indeed; for even with the powerful aid of rotation it has driven the American mathematicians (who have especially investigated the subject) from the old idea of solidity; Pierce taking refuge in the supposition of a fluid, and Maxwell in an aggregation of unconnected particles. The great Roman observer, Secchi, inclines to the idea of a gaseous or vaporous constitution. The faint visibility of the dark side of the ring, when it has been turned towards us, which was remarked by Herschel in 1789, and by Bond and Dawes in 1848, is an additional puzzle, especially the coppery tinge which was detected in it by the latter observer. It seems, from Bond's investigations, that it cannot arise from a twilight produced by an atmosphere surrounding the ring; nor is the direction of the sun's rays favorable to the idea of a slight transparency, which otherwise its astonishing thinness would render very probable. Almost everything connected with this wonderful appendage seems at present involved in impenetrable mystery.

THE APPEARANCE OF THE EARTH FROM VENUS.

It is a curious and pleasant inquiry, what may be presumed to be the telescopic aspect of our globe from the planet Venus or Mercury; and though, of course, demonstrative certainty in the reply is not within our reach, we may be led to some interesting conclusions. We shall, of course, suppose the case of the nearest approach of either of those planets when they pass between ourselves and the sun. In such circumstances, an apparently retrograde motion will bring us up with a great broad disc into their midnight sky, and all our features will lie open before the distant observer's gaze. There can be little question that the distinction of our continents and oceans would be very perceptible from the superior reflective power of the former as contrasted with the absorbent property of the latter, which, as is shown by experiments with the diving-bell, soon extinguishes the solar rays. The general aspect of the land would, no doubt, be various from the effect of local color where sufficiently extensive, and the vegetation of the prairies and pampas would be readily distinguishable from the sands of the Sahara; but diversities on a smaller scale would be merged by distance in a compound gray of the third order of color. The appearance of the water would also be greatly contrasted in different parts, from its varying degrees of depth and consequent translucency. Islands would, of course, be in general perceptible in proportion to their size as brighter specks; but it may admit of a question whether an island, or, indeed, a line of coast, would be in all cases easily distinguished from an adjacent shallow sea. The polar regions of ice and snow would, of course, be strongly marked, with their extension or contraction according to the time of year; but, in consequence of the inclination of the earth's axis, their presentation would differ greatly at different seasons. If the supposed opposition of the earth should coincide with our European summer, the north snows would alone be conspicuous, entering far into the visible hemisphere, but diminishing gradually with the continued action of the sun; if during our winter, the reverse would occur; in spring or autumn each pole would show its white segment at the edge of the disc; but in every case, as our poles of temperature are not coincident with our poles of rotation, and our continental are very different from our insular climates, the brightness of our arctic and antarctic regions would be unsymmetrical in extent, and their aspect would differ materially as different sides of our globe were brought round by our diurnal rotation. The frozen summits of such extensive ranges as the Himalaya or Andes would, no doubt, be perceptible with sufficient optical power; but the shadows of our mountains would, of course, be equally invisible with those in the full moon, and from the same cause; and it does not seem likely that even our largest river-courses would have sufficient magnitude to be seen. As the rotation of our globe, combined with the inclination of its axis, would, in successive oppositions, bring the whole of the surface before the eye, it might at first be thought an easy task to map all its outlines with precision; but the atmosphere would in all likelihood interpose most serious difficulties. From its property of transmitting red light, as shown in our sunrise and sunset, and in the face of the totally eclipsed moon, it will probably communicate a slight ruddy tinge to our disc, like a faint wash of red passed over a drawing; but this hue would be very feeble, if at all apparent, in the centre, coming out chiefly from the oblique transit of the ray through the atmosphere towards the edges of the globe; and it would be immaterial compared with the confusion arising from the local condensation of its watery particles. There can be no doubt that Schröter was mistaken in thinking that accumulations of vapor would appear as dark spots upon a planetary disc; the old Hanoverian confounded the *interior* effect, or that produced upon an eye beneath them, which, of course, would be one of gloom from intercepted light, with the *exterior* aspect to a distant observer, which would be eminently luminous, few bodies reflecting a more intense white light than the upper surface of a densely compacted cloud; and hence those regions of the earth which are sometimes for months together overshadowed by a cloudy pall, must, to an external eye, present a peculiarly white and luminous appearance; while, for a like reason, the edges of the disc, where oblique vision would render vapor more perceptible, would possess not only the ruddier, as before suggested, but the more vivid light. And thus it is easy to see how baffling an impediment our atmospheric variations must interpose in the way of any accurate comprehension and delineation of the features of our globe, and how the configurations which a distant observer would at one time congratulate himself upon having satisfactorily traced, might, after a short interval, be wholly defaced and obliterated, or so intermingled with the outlines of superjacent vaporous masses as to produce a degree of entanglement requiring a long period for the extrication of anything like a reliable result.

THE PRESENCE OF AN ETHEREAL MEDIUM PERVADING SPACE.

In a recent able communication to the *Philosophical Magazine* (London), on the " Phenomena which may be traced to the presence of a medium pervading space," by Prof. Daniel Vaughan, of Cincinnati, Ohio, the author calls attention to the ultimate effects of an impediment due to the presence of assumed ethereal fluid or medium in the dark systems of remote space. In these ultimate effects he finds an explanation of the temporary stars. He regards these celestial apparitions as indicating the existence of the ethereal fluid, and as manifesting the great revolutions to which this fluid leads in the conditions of the bodies in space.

To combat the theory adopted by Arago and others,—which assumes that the ephemeral exhibition of temporary stars is due to the rotation of great orbs, self-luminous on one side, and dark on the other,—Mr. Vaughan urges that to make a partially luminous sphere or spheroid display its brilliancy to the inhabitants of the earth for only seventeen months, while its period of rotation has been estimated at three hundred and nine or three hundred and eighteen years, the surface of the supposed distant sphere must be nearly two hundred million times as great as the part of it sending light to our planet during the period of greatest brilliancy. The light, moreover, must have proceeded from the verge of the invisible disc. And this circumstance, taken in connection with the surprising brilliancy of the star of 1572, together with the invariability of its position, will compel us to ascribe to the spectral orb in question a diameter far exceeding that of Neptune's orbit. Even, therefore, if stellar movements would permit us to suppose the existence of such stupendous spheres, the explanation would be applicable to one or two cases only; so that it is requisite to reject a hypothesis whose claims rest solely on the greater imperfections of others proposed to account for the same phenomena. As a better explanation of the phenomenon in question, Mr. Vaughan teaches that the appearance is more probably due to the dismemberment of a secondary or primary planet, brought by the resistance to its motion in an ethereal medium into fatal proximity of the central sphere, — an exposition which, he maintains, harmonizes in a very decided manner with the astonishing rapidity with which temporary stars attain their maximum brilliancy, and then assume a comparatively slow and gradual decline.

Investigations respecting the necessary course of physical events in the dark systems afford, the author further opines, still more important evidence in regard to the ethereal contents of space. Were the central body composed of solid matter, or surrounded with an atmosphere of oxygen, nitrogen, or carbonic acid, a development of heat and light might be expected to attend the dilapidation of one of the satellites or the ultimate incorporation of its matter with the great orb; but the appearance would not correspond to that exhibited by the temporary stars.

"Admitting that a solid globe, almost as large as the sun, may be rendered so highly incandescent as to shine like the star of 1572 at the period of its greatest brilliancy, it would be impossible for it to cool so rapidly as to become invisible in the course of seventeen months. Besides this, it may be easily shown that if our earth had a diameter of eighty thousand miles, with its present density and superficial temperature, our atmosphere would have its density reduced a millionfold, with an elevation of six or seven miles. Thus the greater mass we assign to the central body, the more narrow must we regard the atmospheric region where light can be developed by aerial compression; and the less display of lustre could we expect from this cause when a satellite fell from its stage of planetary existence. But this difficulty will disappear, when we suppose that the ether of space forms for the several great celestial bodies extensive atmospheres, which are rendered luminous by adequate compression, or rather by the chemical action it induces,— a theory which becomes necessary to account for the luminosity of meteors, and the perpetual brilliancy of suns."

The various arguments in support of the idea of the existence of a pervading ether, while they differ widely in detail from one another, have this in common, viz., that they are based on inference alone, or, as the lawyers would say, on circumstantial evidence. The value of the evidence rests, consequently, on its accumulative character, not on any direct fact. The danger of the evidence lies in the absence of direct fact, and on the suspicion that some day a new and more comprehensive theory of the universe, and the forces by which it is animated, may step in and undo the very foundations of our present learning. Meanwhile, we are acting most judiciously in accepting, on the evidence adduced, the hypothesis of the existence of an ethereal medium. Many a human life has been sacrificed to justice, and many a gigantic human enterprise been accepted, on evidence less clear, and far less demonstrative. While, therefore, we may regret the insufficiency of our knowledge on this particular point, while we may sigh for the day when all these things shall be revealed, we must rest on inference for the present, and remain content.

But granting the existence of an ether of space, the question naturally arises, What is its nature? Is it matter? And, if matter, is it, as such, allied to any form of matter with which we are conversant?

To answer this question we must begin by asking another, which has, indeed, been put for us by Humboldt, and on the primary solution of which all our ability, all our possible reasons for the discovery of the great and ultimate question, entirely turn. This preliminary inquiry suggests, whether, if an ethereal fluid really exists in space, it comes within our reach, — whether, in other words, it commingles, if the term is allowable, with our atmosphere, encircles our bodies, penetrates matter, and, from the regions of the illimitable space, extends into those infinitudes into which even the microscopic eye has not as yet effectually penetrated? This difficult problem is well put by the great German philosopher: —

"The question of the existence of an ethereal fluid filling the regions of space is closely connected with one warmly agitated by Wollaston in reference to the definite limit of the atmosphere, — a limit which must naturally exist at the elevation where the specific elasticity of the air is equipoised by the force of gravity. Faraday's ingenious experiments on the limits of an atmosphere of mercury (that is, the elevation at which mercurial vapors precipitated on gold leaf cease perceptibly to rise in an air-filled space), have given considerable weight to the assumption of a definite surface of the atmosphere, similar to the surface of the sea. Can any gaseous particles belonging to the region of space blend with our atmosphere, and produce meteorological changes? Newton inclined to the idea that such might be the case."

But if the evidence be at all worth anything on which the hypothesis of a universally diffused ether rests, then it must follow, of necessity, in answer to the second question suggested, that the ether of space does extend to the earth itself and to man himself. For if, to take one example, it be true that light is due to the undulations of the circumambient ether, then must the undulating medium be persistent everywhere where light is demonstrable, so that we must accept the idea of its presence immediately around us, in admitting its presence altogether as a part of the universe.

Here, however, speculation, we had almost said, ceases; at all events, reasonable speculation, based on any sufficiency of data, here abruptly ends. It must be confessed that no kind of physical inquiry has led us by experiment to the recognition of any agent constituting a part of the matter around us, to which the term ether, used as regards the ether we are treating of, can be applied. If such a body exists, it is beyond our estimation of all that is material. It has no weight, according to our idea of weight; no resistance, according to our idea of calculating resistance by mechanical tests; no volume, on our views of volume; no chemical activity, according to our experimental and absolute knowledge of chemical action. In plain terms it presents no known reagency by which it can be isolated from surrounding or intervening matter, which is known.

And yet, though all is so far negative to us, we are not without glimpses of the possible nature of a medium such as has been supposed; that is to say, if it exists at all, we may make an estimate of certain of its properties. It is indestructible for one property, and unchangeable; by which we mean that it cannot be assumed to enter into combination, and so to change its original type and character by combination like a common combining elementary gas. As a sequence to this view the ether must be considered as negative in character, permeating matter wheresoever it can gain entrance, and even perhaps adding to the bulk of matter, and communicating to it motion under external influence, but not combining with the parts of matter in any definite bond. Sensitive to all external mechanical influence, it must be susceptible of undulation to the highest degree, and, existing as matter, must take the gaseous type, and represent that type in its most refined ideal; so as to evade, in fact, all our present means of determining it, as material, by experiment; and to be comprehensible only when, accepting for the argument's sake the undulatory theory of light, we make a theoretical estimate of the undulations of light by the side of those of sound. Then truly we may admit, with Mr. Vaughan, that as the medium which conveys light conveys it with nearly a million times the rapidity of sound, "such medium must have a modulus of elasticity almost 1,000,000,000,000 as great as that of common air."

The reader will glean from these observations the immense difficulties which lie in the way of demonstrating by physical means the presence of the ether of space. But it would be very false argument to condemn the theory of the existence of this ether on the ground of the difficulty of demonstration. We will illustrate this by a single observation. We will assume that it were revealed to us beyond contradiction, by some superior intelligence, that an ethereal medium, having, as Mr. Vaughan expresses it, "a modulus of elasticity 1,000,000,000,000 as great as common air," did exist around us; we will suppose that we were further informed that the gaseous medium thus presented resembled one of our recognized bodies, having negative properties,—say, for example, nitrogen. Even then, with all our appliances, we should at this moment fail in being able to make a single demonstration of the existence of such a medium. It would have to us nor weight, nor volume, by which it could be distinguished, nor chemical agency, nor resistance that could be measured. Were we adventurous in science, we might declare a conviction that the ethereal medium was a body negative like nitrogen; in space refined; but in the neighborhood of planets, within the sphere where the specific elasticity of air is equipoised by the force of gravity, more condensed, and more closely resembling a gas, but as yet inappreciable.

Finally, if there is an all-pervading ether, we are tempted to inquire, Of what use is it? The answer here is less difficult to name than in the previous cases, but infinitely more prolonged if followed to its end. If there is an all-pervading ether, its uses are equally all-pervading, and are fitted rather to take description from the poet than the philosopher. We must not attempt the task, but leave it rather to the imagination to conceive,—how a subtle bond connecting sphere with sphere, man with man, and man with all that he sees and recognizes in the universe, — how a subtle matter, through which may be conveyed every touch from the finger of the Supreme, — and how this all-penetrating agent, entering into man as matter, animates him into life, filling him with the transparency of existence, and clothing him with intelligence. These suggestions we must leave. They are philosophical visions, in which, if we travelled too far, all our harder and baser arguments might dissolve and disappear.

ACCURACY OF MODERN ASTRONOMICAL CALCULATIONS.

On the establishment of the American *Nautical Almanac* in 1849, it was found that all the large lunar ephemerides, or tables used by European astronomers, were imperfect, and it was consequently deemed expedient to prepare a new set of tables for use in the preparation of the Almanac in question. The work was accordingly entered upon and completed. A recent writer in the *North American Review* publishes the following striking illustration of the accuracy of the tables thus prepared, and of the fidelity with which they give the moon's position : —

"The smallest round object visible to the unassisted eye subtends an angle of about a minute, and two such objects will, to an ordinary eye, seem like a single object if their distance apart is less than three minutes. To the naked eye the two stars, *E Lyræ*, present the appearance of a single star somewhat elongated; their distance apart is something more than three and a half minutes, yet this seemingly inappreciable space must be divided into sixty portions, in order that each portion may be equal to the average difference between the real position of the moon and that predicted from theory in the tables in question. Now the time of the rising of the theoretical moon will very seldom differ half a second from that of the real one.

"An example of the amount by which a planet must wander from its assigned orbit, to produce a commotion in the astronomical world, is furnished by those anomalies in the motion of Uranus which led to the discovery of Neptune. After being for thirty years a source of perplexity to astronomers, they were measured with such accuracy as to indicate, within a degree, the direction of the planet producing them. Yet if two stars, visible to the naked eye, had moved through the heavens during those thirty years, one keeping in the position of the actual Uranus, the other in that of the theoretical Uranus, the naked eye could at no time have perceived any indication that the two did not form a single star."

THE EXTENT OF OUR SYSTEM OF STARS.

One cosmical question which theoretical considerations have greatly aided us in limiting, is that of the infinite extent of our system of stars. To the reflective astronomer, as he sounds depth after depth of the starry systems, to all appearance bottomless, no subject of speculation would appear more attractive. As in all other questions which we are not able to solve by direct experiment, we must begin by asking what consequences would follow from the affirmative and the negative of the question respectively. Starting from the hypothesis that infinite space was scattered with stars, mathematicians had no difficulty in proving that, unless the light were absorbed in its passage through space, the whole celestial vault would be one blaze of light, brilliant as the noon-day sun, on which the moon and planets would appear as dark patches. It was therefore concluded by Chéseaux and Olbers, that the celestial spaces probably contained some ether, which possessed the power of absorbing light. This theory was subjected to a test by Struve, in his work entitled *Etudes de l'Astronomie Stellaire*, in the following manner. If the stars are equally distributed through space, and are of equal absolute brilliancy, the number of stars of each magnitude would be at least four times as great as that of the next larger magnitude, supposing that no light were lost. An extinction of light would lessen the proportionate number of small stars. Now this is precisely what is found to be the case: whence it is concluded, either that the stars are more numerous in the neighborhood of our system, or that light is absorbed. Considering the former horn of the dilemma very improbable, Struve adopts the latter, though it cannot yet be considered as an established theory. One object of Struve's investigation was to show that the idea of an infinite universe was not incompatible with the appearance of the heavens. But this is not the only difficulty to which the hypothesis of such an infinite universe as we have supposed would lead. Unless heat as well as light is absorbed we should experience a temperature compared with which that of a reverberatory furnace would be as the frozen pole. The principal difficulty, however, would be that resulting from the attraction of the infinite mass of stars. The attractions of the different parts of such a mass could not counterbalance themselves anywhere, and some systems would be exposed to an infinite attraction. True, it is difficult exactly to define what stars would come into this category. At first sight it might appear that, since each star is equally surrounded by an infinite series of other stars, each ought to be equally attracted in all directions. This conclusion would be correct, if the combined attractions of the more distant stars gradually diminished, so as to vanish at infinity. But, although the attractions of the separate bodies do diminish as we increase the distance, yet the entire number which will be contained in a spherical surface, at any given distance, will increase in the same proportion that the attraction will diminish, so that the combined attraction will not vary at all. Now, if we examine the reasoning on which the conclusion cited above is based, we shall find that it tacitly assumes that for every attracting mass of stars on one side of any star, taken at pleasure, there is an equal attracting mass on the other side to counterbalance it. We thus profess to compare two infinite magnitudes, and pronounce them absolutely equal. But two magnitudes can be pronounced absolutely equal only when certain relations exist between their boundaries. Now, by hypothesis, our magnitudes are infinite, therefore without bounds, and therefore without means of comparison, so that the whole reasoning is illusory. Moreover, it is mathematically demonstrable that, if the stars in any one position were in an equilibrium as to the opposing forces, this could be the case in no other position.

It must be understood that we have thus far spoken of the infinite system of stars as scattered indiscriminately, but with a certain ap proach to uniformity, through space. But the hypothesis of an infinite increase does not necessarily involve this arrangement, or any of its attendant difficulties. We need only suppose, with Lambert and others, that the mode of formation which we see carried out in those portions of the universe visible to our eyes is continued to infinity, that out of a proper number of systems of a lower order systems of a higher order are formed, and that the separate systems are always placed at vast distances, compared with the dimensions of the system. The lowest systems in this series are composed of a planet, with one or more satellites, the dimensions of which, astronomically speaking, are inconsiderable. The separate planets are formed into the solar system, being placed at distances of hundreds, or even thousands, of millions of miles. The fixed stars, which are supposed to be the centres of solar systems like our own, are placed at distances so great that the entire dimensions of our solar system are but a point in the comparison. There may be great numbers of other starry systems or milky-ways like ours formed into a system, a collection of these systems into another, and so on, without end. Of course we are now in the domain of pure speculation, as all systems of a higher order than those composed of individual stars must remain forever invisible to mortal eyes, and while man dwells on our planet he has no more means of becoming acquainted with their existence than he has of seeing the inhabitants of Neptune. The subject may therefore be dismissed with the remark, that the arrangement is not, so far as can be seen, carried out with perfect regularity. Other starry systems seem to merge insensibly into clusters, forming part of our milky-way.

THE INCLINATION OF THE PLANETARY ORBITS.

In a recent communication to the British Association, by Professor Hennessy, on the above subject, the author stated, that on consulting a synoptic table of the planetary elements, some law had been obtained for the other elements, but none hitherto for the inclinations of the several orbits. This he conceived arose from the inclinations being set down in reference to the plane of the earth's orbit; for he found that a very remarkable relation manifested itself when they were tabulated in reference to the plane of the Sun's equator. The author had written on the board two tables: one, the ordinary table in reference to the ecliptic; the other, that to which he wished to draw attention, having reference to the plane of the Sun's equator. In the latter, it was seen as a general law that the inclinations of the planetary orbits increased as the distances of the several planets from the sun increased. Thus, the inclination of the orbit of Mercury to the plane of the Sun's equator was but 0° 19′ 51″, while that of Neptune was 9° 6′ 51″; the only considerable deviation from regular progression being found, as might be expected, among the asteroids: of which, if we take Victoria as a type, her inclination is no less than 15° 42′ 15″. The author considered that the fact that the orbits of the larger planets, Jupiter, Saturn, Uranus and Neptune, are not more inclined, would seem to confirm a surmise of La Place, who, in his *Exposition du Système du Monde*, speculates on the order in which the planets were thrown off from the Sun, and supposes that Jupiter, Saturn, etc., were thus formed long before Mercury, Venus, the Earth and Mars. If so, the oblate-ness of the Sun would in its condition at that time have tended more powerfully than in its subsequent or present state to keep the planets near the plane of its equator. The discovery of this law regulating the inclinations of the planetary orbits appeared to him another addition to the class of facts which establish the analogy between the solar system and that of Jupiter and his satellites, it being well known to astronomers that the inclination of the orbits of the latter to the plane of Jupiter's equator was a function of their distances and masses.

ASTRONOMICAL OBSERVATIONS WITH THE SPECTROSCOPE.

Mr. Lewis M. Rutherford, of New York city, communicates to *Silliman's Journal* the results of some analyses of the spectra afforded by the light of several of the planets and of the fixed stars, of which we give the following summary: "The Sun's lines generally find their counterpart in the lunar spectrums. In the spectrum of Jupiter are found two *bands* in the red and orange which are not found in the solar spectrum. It may be that these are absorption bands, due to the action of the atmosphere of the planet, and the application of sufficient optical power may resolve them into lines.

"The star-spectra present such varieties," says Mr. R., "that it is difficult to point out any mode of classification. For the present I divide them into three groups: first, those having many lines and bands and most nearly resembling the Sun, viz., Capella, β Geminorum, a Orionis, Aldebaran, γ Leonis, Arcturus, and β Pegasi. These are all reddish or golden stars. The second group, of which Sirius is the type, present spectra wholly unlike that of the Sun, and are white stars. The third group, comprising a Virginis, Rigel, etc., are also white stars, but show no lines: perhaps they contain no mineral substance, or are incandescent without flame.

"It is not my intention to hazard any conjectures based upon the foregoing observations; this is more properly the province of the chemist; and a great accumulation of accurate data should be obtained before making the daring attempt to proclaim any of the constituent elements of the stars.

"One thought I cannot forbear suggesting: we have long known that 'one star differeth from another star in glory;' we have now the strongest evidence that they also differ in constituent materials,—some of them perhaps having no elements to be found in some other. What then becomes of that homogeneity of original diffuse matter which is almost a logical necessity of the nebular hypothesis?"

NEW ASTRONOMICAL HYPOTHESIS.

A writer in one of the late English reviews submits for consideration the following astronomical hypothesis:—

"Whether M. Maedler's discovery of a central sun round which our whole solar system is revolving with scarcely conceivable rapidity may not afford an instant explanation of the planetary ellipse?

"Every one acquainted with the mere alphabet of astronomy is of course perfectly aware that the ever-memorable problem propounded by Sir Isaac Newton in relation to the planetary orbits expressed itself literally in these *ipsissima verba:*—'To determine the nature of the curve which a body would describe in its revolution about a fixed centre to which it was attracted by a force proportional to the mass of the attracting body, and decreasing with the distance according to the law of gravitation;' Copernicus having previously surmised that the planetary orbits were circular, while Kepler, on the contrary, had suggested that they were elliptical. Every one of us, moreover, delights to recall to mind Newton's almost rapturous amazement when he found that the answer to that problem was the general algebraic expression embracing all the conic sections — the planets revolving in ellipses, the satellites of Jupiter in circles, the comets in orbits both parabolic and hyperbolic.

"Accepting with the reverence due to it every iota of that sublime demonstration, and bearing in recollection, with all homage for Sir Isaac, everything he has written thereupon about the centrifugal and centripetal forces, may we not now ask ourselves anew — now that we are studying the phenomenon of the planetary ellipse by the light of that newly-discovered grander central sun of suns, opened to view so very recently by the researches of M. Maedler, of Dorpat — whether there may not lie near at hand, already within our grasp, a much less recondite and far more easily comprehensible solution?

"Granting, as astronomical science does grant nowadays, that the whole solar system, sun, comets, planets, satellites, are moving, whirling through space at the rate, it is computed, of 150,000,000 miles in a year, — wheeling onwards in the direction of a particular point in the heavens, namely, the star $\frac{\pi}{\lambda}$ in Hercules, speeding on in a circuit of such gigantic dimensions about that mighty central orb (Alcyone, the principal star in the Pleiades) that it requires for the completion of its stupendous orbit the lapse of no less astounding a cycle of years than 18,200,000 — is it not really conceivable, that in the whirling of those concentric rings, the planetary orbits, along the path of that marvellous circumference, the circles would by the very swiftness of their flight be lengthened — that from being circular they become elliptical? — precisely as the revolution of the earth upon its axis causes it to be flattened at the poles while it increases its diameter at the equator, rendering its form no longer a perfect sphere, but rather what is geometrically designated on oblate spheroid. If what may be called with the strictest accuracy the eternal law of celestial dynamics manifests itself thus distinctly by its operation upon solid inert matter, how much more comprehensible that it should be *as* distinctly evidenced through a more elastic medium — not upon an orb, but on an orbit."

NEW VIEWS RESPECTING THE ATMOSPHERE.

M. Quetelet, the well-known Belgian meteorologist, in a recently published work, "*Sur la Physique du Globe*," expresses some views respecting the constitution of the atmosphere different from those hitherto generally entertained. He supposes (with Bunsen and others) that the atmosphere extends to a height of 150 or 200 miles; that the oxygen and nitrogen are kept mingled by the currents of the atmosphere, so that at all accessible altitudes there is no appreciable difference in the proportions of these two gases. He supposes however that it is only the lower portion of the atmosphere which is maintained in this state of agitation; that the upper portion may be perfectly tranquil, and here the proportions of the two gases may change; and they may perhaps be disposed in separate strata in the order of their specific gravities. He supposes that the cirri, the lightest of the clouds, are formed in this lower portion of the atmosphere, near the boundary which separates it from the upper and undisturbed portion; while it is in the upper portion of the atmosphere that shooting stars and auroras appear. The upper portion he calls the *stable* atmosphere, and the lower portion the *unstable* atmosphere. He conceives that by the study of shooting stars we may ultimately arrive at a knowledge of the composition of the stable part of the atmosphere. We observe these meteors at elevations of 140 to 160 miles; they increase in brightness as they approach the earth; they disappear entirely as they approach the lower part of the atmosphere, as if they entered a medium which had not the elements necessary for their continued brilliancy.

He questions whether the time of rotation of the still atmosphere is the same as that of the earth; and suggests that this circumstance may perhaps explain the slow rotation of the magnetic poles of the earth.

As the editor of *Silliman's Journal* has remarked, "physicists will be slow to accept M. Quetelet's novel ideas on the constitution of the atmosphere, unsupported as they are by experiment and in conflict with long-established laws."

INFLUENCE OF TREES UPON TEMPERATURE.

M. Becquerel has made in the Jardin des Plantes, with a sensitive thermometer, certain observations at different hours of the day, by comparison of which it was found that about 3 P.M., when the temperature is highest, the difference sometimes amounted to 2° or 3° in favor of the atmosphere above the tree, whilst at sunrise, after a clear night, the excess was on the other side, on account of the nocturnal radiation. This experiment proves the cooling of trees and the atmosphere surrounding them under the influence of nocturnal radiation. Vegetables near a wood are sooner affected by spring frosts and the cold of autumn than vegetables at a distance from them. Under the influence of solar radiation above the trees, there is a current of warm air ascending during the night, and in the morning a current of cold descends to cool the soil. When the sky is cloudy these differences of temperature are very small. These experiments of M. Becquerel also prove the correctness of the conclusions of Humboldt from the observations upon the temperatures observed at thirty-five stations in North America, extending over 40° in longitude, namely, that the mean annual temperature over this extent of country has not been sensibly changed by the great destruction of wood which has taken place during the time of the observations.

THE WEATHER AND THE SCINTILLATION OF THE STARS.

In a communication recently made to the Paris Academy of Sciences, by M. Liandier, it is stated that the occurrence of storms and similar changes in the weather may be predicted from twenty-four to twenty-eight hours beforehand, by observing the scintillation of the stars, as shown in a telescope. The image of a star in the object-glass is, in fact, a mirror which reflects the condition of the atmosphere through which the rays pass. The best indications of the state of the upper strata of the atmosphere are said to be obtained from a well-defined image of a star of the first magnitude, when near its point of culmination. At first, there may be seen, moving apparently in all directions across the image, vibrations or waves more or less brilliant, and obscure or colored. By examining these waves carefully, it will be perceived that they cross the disc in one direction, thus showing the direction in which currents of air are flowing at that moment in the upper regions of the atmosphere. The telescope may thus sometimes serve the same purpose as a weather-glass.

MEAN TEMPERATURE OF THE EARTH.

The depth at which the annual variations of temperature disappear varies considerably, not only with latitude, but with changes in the nature of the soil and rocks in the same place.

M. Quetelet, the eminent European physicist, in his recent work, "*Physique du Globe*," gives some interesting statistics illustrative of this fact.

Thus this depth is found at Zurich at 83.7 French feet; Strasburg, at 81.6 ft.; Heidelberg, in compact clay, 83.3 ft.; Schwelzingen, in sandy earth, 89.8 ft.; Bonn, 72.6 ft.; Paris (in the Observatory garden), 69.4 ft.; Leith (Mr. Ferguson's garden), 54.7 ft.; Edinburgh, in trap, 55.5, in sand 66.2, in sandstone 96.6; Upsala, 1st series 62.6, 2d series 61.9 feet. The mean of these is 73.1 ft. Only below this mean depth do we encounter the central heat of the earth, which corresponds to about 1° for each 48 feet, and the effect of which on the diurnal and annual variations above the plane of no variation must be inappreciable.

RAIN FOLLOWING THE DISCHARGE OF ORDNANCE.

The following communication on the above subject has been made to the Manchester (Eng.) Philosophical Society by Mr. Baxendale:—

"New facts drawn from the American war have been adduced in support of the view that a violent concussion of the air by the discharge of heavy artillery has a tendency to cause a copious precipitation of rain. (See *Annual of Scientific Discovery*, 1862, p. 392.)

"Now, if we may be allowed to regard this effect as an established fact, it seems to me to be one of some interest in connection with the disputed question whether, in thunder storms, a discharge of lightning is the cause or the consequence of the sudden formation of a heavy shower of rain. Almost every day's experience, in this climate at least, shows that the production of rain is not dependent upon sudden discharges of electricity from the clouds; and no evidence has ever been brought forward to prove that a high degree of electrical tension in a cloud has a tendency to prevent the resolution of the cloud into rain. Heavy showers often fall from highly electrified clouds without any visible discharge of electricity taking place. We are, therefore, not entitled to assume that the sudden diminution of the electrical tension of a cloud by a lightning discharge can have any material influence upon the rain-forming processes going on in the cloud. As, however, very heavy showers of rain do almost invariably follow lightning discharges, it seems necessary to seek some other cause to account for them. But if we admit that a violent concussion of the air has a tendency to facilitate the conversion of rain-forming material into actual drops of rain, then we may well suppose that the violent concussions produced by lightning discharges, acting on such enormous and dense masses of rain-forming material as are usually collected in heavy thunder clouds, are amply sufficient to produce these sudden and heavy showers of rain.

"I am aware that the effect of a discharge of ordnance is usually supposed to be produced by an upward current of air caused by the heat and the gases evolved during the combustion of the gunpowder; but as an hour's sunshine through an opening in the clouds, especially when the sun is at a considerable altitude, would produce a much greater effect in heating and increasing the bulk of the air, this cannot be received as the true explanation of the mode in which the effect of a discharge of heavy artillery is produced."

RECURRING MONTHLY PERIODS AND PERIODIC SYSTEM OF THE ATMOSPHERIC ACTIONS.

The above is the title of a recent English publication, by W. H. Webster, a surgeon in the Royal Navy, who has devoted much attention to meteorology and collected an abundance of data from all quarters.

Mr. Webster believes himself to have discovered that the weather is constantly marked by *recurrences*, separated by a solar month of 30½ days. Accordingly, to him the same days of the month, or *nearly* the same days, are *critical*, — either show the highest or lowest barometer of the month, or else the highest or lowest thermometer. This he affirms he has verified in an enormous number of instances, of which he gives a few. Of course we neither admit nor deny this discovery: our business is only to describe it. We shall show our readers what he gives us, from observations, for the year Sept. 1819 to Sept. 1820. It appears that, 1819, Sept. 20 was the highest day of the barometer for the month; Oct. 22, Nov. 20, Dec. 22, were the lowest. Feb. 15, 1820, and March 15, were highest days. Feb. 24 and March 24 were lowest days; April 23 was a highest day. May 1 and June 1 were lowest days; July 1 was a highest day. As to the thermometer, Jan. 15 and Feb. 17 were lowest days. March 6 and May 5 were lowest days; but April 5 was highest. March 30 was highest, April 30 lowest. July 31 was highest, August 29 was lowest.

Mr. Webster sets aside the supposed influence of the moon altogether, his periods being solar.

OBITUARY

OF MEN EMINENT IN SCIENCE. 1862.

Baldwin, James F., a distinguished American engineer.

Barlow, Professor, an eminent English physicist, well known for his experiments on the strength of materials.

Barrett, Lucas, Director of the Geological Survey of the British West Indies; drowned while investigating the structure of coral reefs by a diving-bell.

Biot, M., one of the most illustrious scientific men of France.

Brodie, Sir Benjamin, President of the Royal Society, G. B.

Bronn, Dr. Henrich G., the well-known German paleontologist.

Brownell, Dr. Charles C., botanist to the Pethrick Expedition to the Sources of the Nile.

Buckle, H. T., author of the "History of Civilization."

Curtiss, John, an English entomologist.

Ellet, Charles, Jr., a distinguished American engineer; died of wounds received in a naval engagement on the Mississippi.

Gasparin, M. De, a French physicist.

Hammel, Dr., a well-known Russian scientist.

Herrick, Edward C., of New Haven, Conn.

Hosking, Professor, an English writer of note on architecture and engineering.

Jacob, Capt. W. S., astronomer of the East India Observatory, India.

James, C. T., inventor of James's rifled cannon projectile: killed by a premature explosion.

James, Dr. Edwin, best known as the botanist and historian to Long's Expedition to the Rocky Mountains in 1820; and a naturalist of eminence.

Leonhard, Professor, a German geologist and writer, associate of M. Bronn.

Manross, Newton Spaulding, an American mining engineer and chemist; killed at the battle of Antietam.

Maudslay, Joseph, a celebrated English inventor and engine-builder.

Mitchel, O. M., the astronomer, and General, U. S. A.

Montbeliard, M., a French naturalist; died in the jungles of Tonquin.

Nesbit, Professor, an English agricultural chemist.

Parkman, Theo., an American chemist, killed in battle.

Perley, W. H., of New Brunswick; a naturalist, well known for his investigations in relation to fish and fisheries.

Prout, Hiram A., Dr., of St. Louis, an American naturalist.

Renwick, Prof. James, of New York.

Robinson, Prof. Edward, an American philologist.

Ross, Alexander M., designer of the Victoria Tubular Bridge, Montreal.

Ross, Sir James Clark, the arctic navigator.

Senarmont, Henri De, Professor of Mineralogy, School of Mines, Paris.

Serres, Marcel De, an eminent French geologist.

Stevens, Gen. Isaac T.; distinguished for his surveys and explorations of Northern America; killed in battle.

Stewart, Thomas H., an English naturalist.

Thoreau, Henry D., an American naturalist.

Traill, Dr., of Edinburgh, author of a well-known work on Medical Jurisprudence.

Vicat, Louis Joseph, a distinguished French engineer, best known for his reresearches into the nature of cements.

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