In short, as, in the analysis of the mineral kingdom, we designate, as elementary, those substances which we cannot analyse further; so, in examining organic products, those substances which cannot be simplified, without destroying their most important characteristics, are to be viewed, as the elementary principles, by which the nature of compounds is to be understood and described.

By the distillation of vegetable substances, they are easily resolved into their ultimate elements. These, I have said, are, for the most part, hydrogen, oxygen, and carbon. Some few vegetables, exhibit nitrogen as a constituent. The alkalies, and some of the earths, or their elements, besides still more minute portions of other matter, are also generally found in vegetables. But, hydrogen, oxygen, and carbon, are, in quantity and importance, greatly predominant.

It is a marked distinction, between inorganic, and organic products generally, that the one cannot, like the other, be reproduced by art.

This incompetency in chemical skill, has caused the results of chemical analysis to be questioned. Rousseau, having heard Rouelle lecture on farinaceous matter, said he would not confide in any analysis of it, till corroborated by its reproduction from the alleged elements.

Those, who have any acquaintance with modern chemistry, will not be so skeptical. When diamond and charcoal, are burned under different bell glasses, in different portions of the same oxygen gas, and, in lieu of them, carbonic acid gas is found, in each vessel—who would hesitate to admit both substances to consist of carbon, because this element cannot be recovered in its crystalline form?

I pointed out, early in my course, the very great discordancy of the habitudes of carbon, hydrogen, and nitrogen, with caloric—that, while the two latter cannot be obtained, per se, uncombined with that cause of the repulsive, or the aëriform state, charcoal can only, by the most intense galvanic ignition, be united with it, to a sufficient degree to become aëriform.

rine does not act, until, by heat, their hydrogen is separated more or less from the carbon. Where water is present, its decomposition is always slowly effected by chlorine, especially when any matter attractive of oxygen may be present, as in the case of vegetable colouring matter. Hence the efficiency of chlorine in bleaching.

Iodine unites with starch, without decomposing it—producing a deep blue.

The metals of the alkalies, destroy vegetable matter containing oxygen as an essential constituent, by combining with this principle, and liberating hydrogen. Fluoric, fluoboric, and sulphuric acids, at moderate temperatures, destroy organic matter, by their attraction for water; in which respect, they evidently do not act as acids, but have an effect analogous to the dry alkaline hydrates, and desiccated chlorides.

In like manner, sulphuric acid, hydrate of potash, and the chloride of calcium, absorb the elements of water from alcohol, and discolour it, by evolving a carbonaceous matter.

The muriatic acid acts feebly on organic substances; but, so far as it does act, it appears also to operate by its affinity for water.

The nitric acid, on the other hand, has no other effect, than to impart oxygen—giving rise to the same products as combustion; a result, which ought not to excite surprise, as this acid is, in effect, composed of atmospheric elements, condensed into the fluid form, and containing an excess of that principle which is the most active. Owing to the volatility of nitric acid, many substances cannot be completely oxygenated by it, unless after several distillations. Repeatedly distilled from sugar, it produces malic acid first, and then oxalic acid, and finally water and carbonic acid. These ultimate results, are inevitably consequent to the ignition of the nitrates with dry vegetable substances—as, in this case, the alkali detains the acid, until the heat is adequate to produce a rapid reaction.

to that by which Scheele procured the citric acid,) by saturating lime with apple juice, and decomposing the mallate of lime by sulphuric acid.

Oxalic Acid derives its name from the Oxalis Acetosella. It is crystallizable—not very soluble—and takes lime from all its combinations.

This acid combines with potash in three proportions—the quantity of acid being as 1, 2, and 4. Hence the appellations, oxalate, binoxalate, and quidroxalate.

The salt of sorrel is a binoxalate, consisting of one atom of potash, with two atoms of oxalic acid.

Oxalic Acid is a poison. Magnesia, or bicarbonated alkalies, are the best antidotes. In default of the bicarbonates, a solution of pearlash, or an infusion of wood-ashes, or even a solution of soap, should be ventured.

Oxalic Acid is no more the acid of sugar, than of various other substances from which it may be made.

Malic Acid, and Acetic Acid, are no less the acids of sugar, than the Oxalic—as they are both produced from sugar by the same process.

OF SORBIC ACID.

An acid is found in the berries of the mountain ash, to which this name has been given. It is now alleged to be identical with the Malic acid.

PRINCIPAL NATIVE VEGETABLE ACIDS.

The following are mentioned, by Henry, as the principal native acids:—Citric, Gallic, Malic, Sorbic, Tartaric, Oxalic, Acetic, Prussic, Phosphoric.

OF CITRIC ACID.

The name of Citric Acid discloses its origin. It exists in the lime and lemon, in union with mucilage and the malic acid. This combination is so intimate, as to render it impossible to separate the acid, without first uniting it with some other matter. Alcohol is the most ready agent for this purpose, as it combines with the acid, and precipitates the mucilage. The alcoholic solution, thus obtained, does not yield crystals, even after evaporation, re-solution in water, and evaporating the latter fluid. Scheele pointed out, that the most efficient mode of obtaining this acid pure, is to saturate the juice of lemons, with chalk or whiting, and decomposing the citrate of lime, thus formed, by sulphuric acid, duly diluted.

OF GALLIC ACID, OR ACID OF THE GALL NUT.

An aqueous infusion of galls, yields Gallic Acid in crystals, by exposure. Pounded galls yield it by sublimation.

The infusion of galls contains the tanning principle, called tannin, and Gallic Acid. Muriate of tin precipitates the tannin—a portion of the oxide remaining united to the acid.—This oxide may be precipitated by sulphuretted hydrogen, and the Gallic Acid crystallized by evaporation.

Fresh precipitated earth of alum, will also take the tannin and other matters from a solution of galls, allowing the acid to be crystallized by evaporation.

There is some obscurity and contradiction, with respect to the properties of this acid. Henry informs us, that it precipitates most metals, besides the aqueous solutions of lime, barytes, and strontites, and the acid solutions of glucine, yttria, and zircon ; while Thenard alleges, that among all the salts, those of the deutoxide and tritoxide of iron, are alone decomposed by pure Gallic Acid. It is when united to tannin, that it displays the powers ascribed to it by Henry—as it then precipitates solutions of copper, tin, lead, titanium, iron, mercury. We are indebted to this combination, of tannin with Gallic Acid, and tritoxide or red oxide of iron, for ink.

OF TARTARIC ACID.

The Tartaric Acid, named from tartar, (or the residuum of wine, whence it is principally obtained,) is found in many vegetables. In the tamarind, it predominates; and it forms an exudation, on the berries of the sumach. It exists in the lees of wine, in the state of super-tartrate of potash; and, when freed from impurities, is sold in the shops under the name of cream of tartar. When, to 24 parts of this salt, 18 of sub-carbonate of soda are added, Sal Rochelle is produced; and, in like manner, emetic tartar, by saturating the excess of tartaric acid with oxide of antimony. Tartaric Acid is procured from cream of tartar in fine crystals, by saturating the excess of acid with chalk, and decomposing the precipitate by diluted sulphuric acid. The neutral tartrate left, may be decomposed by quick lime, or chloride of calcium, and the resulting tartrate of lime, will yield the acid in the same way as the precipitate by chalk.

OF BENZOIC, PRUSSIC, PHOSPHORIC, AND KINIC, ACIDS.

In addition to the acids already spoken of, we ought to notice, as important among the vegetable acids—the Benzoic, the Prussic, the Phosphoric, and Kinic, Acids. Others are mentioned by Henry, which are not sufficiently striking, to make it important to remember them. The Prussic and Phosphoric acids, more appropriately the products of animal matter, are at this time merely worthy of attention, as being among those of vegetation.

It appears, that Phosphoric Acid minutely pervades most vegetable substances, especially the coverings of seeds.

The Prussic Acid, has been detected in water distilled from bitter almonds, laurel leaves, and peach leaves and blossoms. To the aroma of the latter, its smell has a striking resemblance.

Laurel water has long been known, and used, as a poison. Water distilled from peach leaves, has been used to impart an agreeable flavour to food. Some, which had been kept for this purpose, being given by mistake to one of my children, was productive of unpleasant symptoms. The consequences might have been much more alarming, had not vomiting mitigated the evil. Some peach-leaf water, prepared by Mr. Wetherill, gave, in my presence, indications of prussic acid.

Instances have been mentioned, where noyeau, a cordial made from the kernels of bitter almonds, has proved poisonous.

The Benzoic Acid is a concrete, volatile acid, existing in Gum Benzoin, or Benjamin, from which its appellation is derived. From this gum the acid may be extricated, by sublimation, or by trituration with lime, digestion with water, and precipitation by muriatic acid.

The presence of Benzoic Acid, characterizes, what is now considered by chemists as a balsam. There are three balsams formed, by its union with particular resins—Gum Benzoin, already mentioned, Styrax, and the Balsam of Tolu.

The word Balsam, has, however, been used heretofore, to designate resins rendered soft or semi-fluid by an essential oil.

An acid, called the Kinic, exists in the Peruvian bark, in union with lime—also in combination with certain alkalies, to which the bark owes its efficacy.

OF FIXED OR FAT OILS.

Oleaginous substances, like olive oil, castor oil, fat, lamp oil, which cannot be distilled unaltered, are called Fixed; while those are called Volatile, which, like the oil or spirit of turpentine, petroleum, cajeput, &c. may, without change, go through the distilling process.

Among the most remarkable of the vegetable oils, are those of the olive, of linseed, poppy-seed, rape-seed. Being procured by expression, they contain mucilage. To the presence of this, the author of the Text Book attributes their liability to become rancid. I have kept a solution of gum arabic for a year, without its acquiring any rancid savour. Rancidity, I suppose to arise from a sort of slow combustion—oil becom-

and hydrogen, and a small per centage of oxygen. Nitric acid acts with great energy on them, and renders them thicker by imparting oxygen. Chlorine has, indirectly, the same effect. By combining with hydrogen, it increases the proportion of oxygen, in the compound.

The Fixed Oils, especially the drying oils, have the property of inflaming with nitric acid, and entering into combustion with lampblack, or other light carbonaceous matter—also with cotton, wool, flax—and, more lately, inflammation has been discovered to arise, from their mixture with ashes.

I stated above, that every Fixed Oil, appears to be decomposable by heat, or refrigeration, into a less fusible, and a more fusible, portion. It appears, by some experiments made in France, by Chevreul, that vegetable and animal oils, are composed of two different matters—both soluble in hot alcohol, but one of them much less so in cold alcohol. Hence, by the agency of this fluid, they have been separated. The less soluble substance is called Stearin, and the other Elain. Each of these, in the process of saponification, gives rise to an acid, (the margaric, and oleic,) which, combining with the alkali, constitute soap. Another matter is at the same time liberated in small quantity, called the sweet principle, of oils or fat.

OF THE VOLATILE OR ESSENTIAL OILS.

The Volatile Oils, (with the exception of those from the rinds of lemons and oranges, which are procured by expression,) are separated from the vegetable substances, in which they are created, by distillation with water. In consequence of the attraction between the aqueous particles, and those of the Volatile Oils thus procured, the latter pass into the state of vapour, at much lower temperatures than they would otherwise.

The Volatile Oils have usually a penetrating smell, and an acrid taste—a characteristic, in which they are the opposite of the Fixed Oils. When pure, they may be evaporated from any surface on which they may be dropped, leaving no stain.

soft crystalline mass, from which, by allowing it to drip for some days, about 20 parts of a colourless acid liquor is obtained, charged with many crystals, and 100 parts of a white, granular, crystalline substance, which so much resembles Camphor, in odour, and volatility, that it has received the same appellation. It seems to be a combination of the acid gas, and the volatile oil.

Artificial Camphor is lighter than water. It does not redden litmus. It may be sublimed, but not without partial decomposition. By sublimation through an incandescent tube, it is resolved into the substances of which it was made. It dissolves in alcohol, and is precipitated from it by water, unchanged. Nitric acid disengages chlorine from it.

OF RESINS.

According to Henry, Resins are the inspissated juices of certain plants. I should prefer to say, that Resins exist in the juices of certain plants, in union with essential oils, from which they may be separated, by evaporation or distillation.

Resins cannot be distilled, without decomposition. They are dry, brittle, and inflammable—insoluble in water, but are generally soluble in alcohol, in ether, in essential oils, in alkalies, and in acids. Probably, they may all be combined with fixed oils, (especially Rosin,) but with various degrees of facility.

Copal is not soluble in alcohol, unless camphorated. At a temperature, adequate to its fusion, if Copal be dropped into linseed oil, equally heated, a compound is formed, which, exposed to the air, gradually hardens—and hence its great use as a varnish.

Common Rosin, or Resin, exudes from various pines, especially the Pinus Australis, in union with oil of turpentine, which is distilled from it.

It seems more proper, to use the word *Rosin*, to designate this species—since the formerly synonimous word, Resin, has been applied to the genus, which Rosin characterizes, in all the most prominent properties.

Strong sulphuric acid decomposes Resins. Nitric acid, by long digestion on them, produces tannin. They are dissolved by acetic acid, and precipitated from it by water.

Resins are of much use for varnishes, when dissolved in turpentine, alcohol, or drying oils.

OF FECULA, OR STARCH.

A substance, of which Starch is a good specimen, and of which the generic name is Fecula, may be obtained from the meal or flour of grain, from the roots of the potatoe, and other vegetables. It is, more or less, a constituent of vegetables in general. When the farinaceous matter, procured from such sources, by rasping or grinding, is washed, the Fecula is suspended, and subsequently deposited.

In the case of wheat, and other grain of a like nature, a fermentation is required, to liberate the Fecula from the other matters entangling it.

Fecula forms a black colour, with a great quantity of iodine —a blue, with less—a violet, with still less—and even a white, when the iodine is at a minimum.

It does not combine with cold water, but forms a viscid fluid with hot water. Alcohol and ether have no action on it. Diluted sulphuric acid, converts it into sugar. It dissolves in cold nitric acid; but, heated with it, yields malic or oxalic acid. A slight torrefaction changes its nature, so that it may be used as a substitute for gum. Triturated with potash, fecula acquires the property of dissolving in cold water. The solution is clouded by acids. Its gelatinous solution by hot water, digested with sub-acetate of lead, forms a combination with the protoxide of that metal.

OF GLUTEN.

The substance left, after washing away the starch from wheat flour, is called Vegetable Gluten. It is to destroy the Gluten, that fermentation is required in starch making.

There are considerable differences in Wax, as to fusibility, colour, &c. White Wax is produced by a bleaching process, analogous to that by which linen is whitened. It is exposed, in thin lamina, to chlorine, or the air.

Wax is insoluble in water. Boiling alcohol dissolves about one-twentieth of its weight. It retains, on cooling, only $\frac{1}{100}$, and this precipitates, on adding water. Ether, when boiling, takes up one-twentieth. The alkalies convert it into a species of soap. Acids do not act on it—hence it is of great use to defend corks, and other substances, exposed to them. It is the best material for candles, owing to its yielding a tolerably pure carburetted hydrogen, and being less fusible than tallow.

OF THE NEWLY DISCOVERED VEGETABLE ALKALIES.

The discovery of this class of substances, is of the highest importance to mankind. It has enabled the physician, to avail himself of the active principles of some of the most powerful of his remedies, with a certainty, which was before unattainable. The patient, in lieu of being nauseated, and even injured, by doses, of which, the greater part, perhaps the whole, may be inert, if not injurious—has to swallow nothing that can be inefficacious, when judiciously prescribed.

The following are the Vegetable Alkalies, now alleged to exist—in the third edition of Magendie's Formulary :

Morphine, Narcotine, Strychnine, Brucine, Emetine, Cytisine, Cinchonine, Quinine, Esculine, Veratrine, Solanine, Atropine, Daturine, Hyoscyamine, Delphinine, Picrotoxine, Gentianine, Lupuline.

To these words, agreeably to usage, or analogy, in the case of *Morphia*, and *Strychnia*, and other alkalies, we must, in English, affix the termination *a*, to the words, instead of *e*, or *ne*.

But, as English authors do not agree, in their mode of translating these names, and as it were useless to change them, I shall adhere, literally, to the appellations given by the French chemists. At the head of each *alkali*, the French names, and the different names used in England, will be given.

called Strychnine. It may be developed, by a process, similar to that used for morphine, above detailed. It was originally obtained, by Pelletier and Caventou, by subjecting the bean of the Strychnos Ignatia, duly rasped, to nitric ether, in a Papin's digester, to remove fatty matter, and subsequent exposure of the residue to alcohol, in which the Strychnine, in union with an acid, dissolves. The alcohol, being evaporated, and the residuum dissolved in water, the addition of potash, caused the alkali to precipitate. It was afterwards washed in cold water, and re-dissolved in alcohol, from which it crystallized, by evaporation.

The colour of Strychnine is white. Its taste is intolerably bitter, leaving a metallic impression in the mouth. It is a terrible poison; very small quantities, producing tetanus, to a fatal extent.

OF BRUCINE, BRUCINA, OR BRUCIA.

This alkali, exists in the bark of the Brucia Antidysenterica. This bark was first subjected to sulphuric ether, and afterwards to alcohol. The alcohol being evaporated, afforded a dry residuum, which was dissolved in water. The solution in water, was saturated with oxalic acid, and evaporated to dryness. The residue was the oxalate of Brucine, disguised by colouring matter, which was removed by alcohol.

The oxalate of Brucine was decomposed by lime, or magnesia, either of which forms an insoluble salt with oxalic acid; while the Brucine is soluble in 500 times its weight of boiling water, or in 850 parts of cold. Hence it may be separated, from the insoluble oxalate, by water.

Brucine crystallizes, in oblique prisms, with parallelograms for their bases. It is less bitter than strychnine, but its taste is more acrid and durable. It melts, when heated a little above 212°, and congeals, on cooling, into a mass resembling wax. It neutralizes acids, affording a distinct class of salts. On animals, its effects are analogous to those of strychnine, but less violent.

to sulphuretted hydrogen, to precipitate any lead which it might contain. The solution, then, with magnesia, gave a precipitate, from which, alcohol took up Veratrine, which was afterwards obtained by evaporation.

Veratrine is white, pulverulent, and inodorous, but nevertheless poisonous, when inhaled, producing violent and dangerous sneezing. Its taste is not bitter, but excessively acrid. In minute quantities, it produces intolerable vomiting, and sickness—and in larger doses, would certainly be fatal.

OF SOLANINE, SOLANINA, OR SOLANIA.

This name has been given to an alkali, lately discovered in a species of the Nightshade, (Solanum Nigrum,) and in the Bitter-sweet, (Solanum Dulcamara.)

The filtrated juice of the berries of the Nightshade, is digested in ammonia: a precipitate, which results, is washed on the filter, and digested in boiling alcohol. After the evaporation of this fluid, Solanine is obtained, in sufficient purity. It is a white, opake, pearly powder, which is inodorous, slightly bitter, and nauseous. Its acid solutions are more bitter. Its salts are uncrystallizable. In cold water, it is insoluble—and hot, dissolves only a small proportion. It restores the colour of litmus, reddened by an acid. It causes vomiting, first—afterwards, sleep.

OF ATROPINE, ATROPINA, OR ATROPIA.

This is an alkali, procured from a decoction of the leaves of the Atropa Belladonna, or Deadly Nightshade. Two pounds of the leaves, were boiled in successive portions of water, which being united, and sulphuric acid added to the whole, the liquid resulting was filtered, and yielded a crystalline precipitate with potash. This precipitate, repeatedly dissolved in acids, and precipitated by alkalies, gave pure Atropine.—Thus obtained, it is snow-white, and quite tasteless. It is,

derives from it an acrid taste, though it does not dissolve any appreciable quantity. By combination with acids, it forms neutral salts, which are soluble in water, and very acrid and bitter.

OF PICROTOXINE, PICROTOXINA, OR PICROTOXIA.

From a strong infusion of the Cocculus Indicus, a white crystalline powder was precipitated, by the addition of ammonia in excess. This powder, washed with cold water, and subjected to alcohol, yielded a solution, which, on being evaporated, deposited beautiful silky needles. A similar result was obtained, from an alcoholic infusion of the seeds, by magnesia, which caused a grayish precipitate—from which, alcohol dissolved a matter, crystallizable by evaporation.

In either way obtained, the crystalline precipitate is Picrotoxine: an alkali, which constitutes the poisonous principle of the seeds, from which it is procured.

Picrotoxine is white. Its taste, disgustingly bitter. One hundred parts of boiling water, dissolves only four of Picrotoxine, and one-half of this precipitates, on cooling. Alcohol, of about 810° s. g. dissolves one-third of its weight of this alkali. With sulphuric acid, it formed a salt, in fine silky filaments: also, a neutral compound with nitric acid, which does not appear to have been crystallizable. With muriatic acid, it forms a neutral, insipid, and crystallizable salt. It also forms crystallizable salts, with the phosphoric, acetic, tartaric, and oxalic acids.

Picrotoxine is a most virulent poison.

OF ACONITINE, ACONITINA, OR ACONITA.

From the Aconitum Napellus, or Wolfsbane, the active principle has been extracted. It has received the name of Aconita, agreeably to the English account of it, which is the only one I have seen. It is, of course, liable to be called Aconitine, or Aconitina. It is supposed to be an alkali.

during the spontaneous decomposition of flesh, than from vegetable matter, under the same circumstances. Hence the smell of sulphuretted hydrogen, attendant on animal putrefaction.

The most prominent proximate principles of animal matter, distinguishable by that delicate analysis, which has been mentioned as necessary in this department of Chemistry, are..... Fibrin, Gelatine, Albumen, Mucus, Urea, Resin, Sugar, Oils, and Acids.

OF FIBRIN.

Fibrin exists in the chyle, and in the blood, and forms the principal part of muscular flesh. It is, therefore, the most abundant animal substance.

To obtain Fibrin, Thenard advises, that blood, as it flows from a vein, should be beaten with a handful of birch twigs. Each of these, will become loaded with a number of long red filaments, which, by washing in cold water, are whitened and purified.

Fibrin is solid, white, insipid, inodorous—heavier than water—neither acid, nor alkaline—while wet, elastic—when dry, hard and brittle, becoming of a yellowish hue. By distillation, it yields much carbonate of ammonia, and a very bulky shining charcoal, which it is difficult to burn, but which, being burned, leaves a residuum of the phosphates of lime and magnesia, and of the carbonates of lime and soda.

Exposed, in an open vessel, to the action of water, occasionally renewed, Fibrin rots—leaving more or less residue, accordingly as it may have been more or less interlarded by fat. If kept in alcohol for some time, it yields an adipocerous substance, which exists in solution, but precipitates, on adding sufficient water. Ether produces the same results, more speedily. With muriatic acid, it forms an acidulous compound, which may be neutralized, by washing. Its habitudes with sulphuric acid, are similar.

Weak nitric acid, disengages nitrogen gas and oil—and, after about twenty-four hours, converts it into a pulverulent

conjecture correct, cold water ought to coagulate Albumen—and heat could not, unless the alkali were volatile. With most of the acids it combines, producing, generally, insoluble compounds. Hence a very minute quantity, disseminated in water, may be detected, by nitric acid. Phosphoric and acetic acids, do not have this effect. It is precipitated from blood, by acids—and the precipitate re-dissolves, on adding ammonia.

According to Thenard, almost all the metallic salts afford precipitates, with Albumen. These are flocky, and composed of oxide, with some acid, unless in the case of the chlorides and iodides. As these precipitates, are almost destitute of action on the animal system, Albumen has been suggested, as an antidote for metallic poisons.

Corrosive sublimate and Albumen, are, reciprocally, excellent tests for each other; and, from the same cause, the one is an antidote for the other.

Albumen, is coagulated by alcohol: tannin, precipitates it.

Albumen holds, as a constituent, a minute portion of sulphur: hence silver spoons are tarnished by eggs. It is of great use, in clarifying sirups. By mixing with them, while viscid, it envelops any feculent matter, with which it may come in contact—and the union continues, until coagulation ensues, and renders it easy to effect a removal of the compound. It clarifies wine, in like manner—excepting, that the coagulation results, in this case, from the presence of alcohol.

As obtained from blood, or eggs, it forms a very tenacious lute, by admixture with hydrate of lime.

OF GELATINE.

Gelatine, agreeably to the high authority of the French chemist, Thenard, to whom, I am principally indebted, for the substance of my Lectures on Organic Chemistry—never makes a part of the animal humours; yet, the matter, proper for its production, exists in all the soft parts. In this state, it is to be found in the muscles, skins, cartilages, tendons, aponeuroses. The membranes, contain a great quantity—the bones, about half their weight.

Gelatine displays no acidity. Nor does it, like albumen, show any trace of an alkali. It is heavier than water—tasteless, colourless, and inodorous; and its ultimate elements, resulting from fiery analysis, are the same as those of albumen, and fibrin. In its habitudes with water, it differs from albumen—being very soluble in boiling water, and difficult to dissolve in cold water. One part, dissolved in one hundred of boiling water, stiffens completely, on cooling—and one part, with one hundred and fifty of boiling water, becomes, as it cools, gelatinous. "This jelly," says Thenard, "sours, liquefies, and putrefies in some days." I have not found this true, in the case of Ichthyocolla, which is the most perfect Gelatine.

Several of the salts and acids, have the property of precipitating Gelatine, but not so unequivocally, as to be good tests of its presence. It is much more soluble in acetic acid, than in water. It is partially precipitated, by alcohol—and totally, by tannin. Alcohol, precipitates it, by taking away the water: tannin, by forming a leather, which is insoluble.

Chlorine, also, produces, with Gelatine, a flocky precipitate.

Gelatine is not acted on, by alcohol, oils, or ether.

By boiling with diluted sulphuric acid, Gelatine is susceptible of conversion into a sugar, which resembles the saccharum of milk, more than cane sugar—especially, in not being susceptible of fermentation.

Gelatine, in the form of Joiners' Glue, is manufactured, for the purposes of the arts, from the clippings of skins, and the ears of animals butchered for the market. These substances, freed from hair and oil, and boiled for a long time, yield a solution of glue, which, when sufficiently concentrated by ebullition, hardens as it cools.

The Gelatine of bones, may be obtained, by the action of water, with heat and pressure. On the phosphate of lime being removed by muriatic acid, the Gelatine becomes soluble in boiling water.

Ichthyocolla, or isinglass, is obtained from the bladder of a species of sturgeon ; and, inferior kinds, from other parts of the same, or of other fishes. It is the finest specimen of Glue, or Gelatine.

The Glue, from bones, is alleged, by Thenard, to be the next best in quality, and is now obtained, extensively, in France.

PORTABLE SOUP. JELLY OF CONFECTIONERS.

OF MUCUS.

The term, Mucus, in an enlarged sense, is applied to the fluid, which lubricates the mouth, œsophagus, stomach, intestines, and other passages of the body.

It differs from albumen, in not being liable to coagulation ; nor does it gelatinize, by concentration. Neither tannin, nor corrosive sublimate, affect it. Sub-acetate of lead, renders its solution opake, and afterwards causes a precipitation.

OF UREA, OR THE CRYSTALLIZABLE MATTER OF URINE.

A substance exists, in the Urine of animals, to which, the appellation of Urea has been given.

Urine, is evaporated to the consistence of sirup, by a very delicate management of fire. Nitric acid, is next to be added, by little, and little. The mixture is to be agitated, and placed in an ice bath, to congeal ; when a crystalline combination is formed, by the acid and the Urea. The crystals, thus procured, are to be washed with ice-cold water, and cleansed, by allowing them to drip, and pressing them between the folds of blotting paper. The Nitrate of Urea, is afterwards redissolved, and again precipitated, by sub-carbonate of potash.

Diabetic Sugar, according to Dr. Henry, is more analogous to that of vegetables, than to the saccharum of milk. It approaches to grape sugar.

OF ANIMAL OILS.

Animal Oils, are, generally, less fluid than those of vegetables—being, usually, solid. The whale, nevertheless, and several kinds of fish, yield Oils, at least as fluid, as the oleaginous products of vegetation. Spermaceti, however, (a fatty product of the whale,) is less fusible than tallow—being, in its qualities, between tallow and bees-wax.

OF ADIPOCIRE.

Muscular flesh, under certain circumstances, has been converted into a substance, resembling spermaceti.

This transmutation, was first well observed, on opening a grave, at Paris—in which, a large number of bodies had been buried. They were found, converted into a matter, in its nature intermediate between fat and spermaceti—to which, the name of Adipocire has been given.

It has been alleged, that running water, and, still more, nitric acid, will convert fibrin into Adipocire.

OF SUET—TALLOW—LARD.

Suet—Tallow—Lard—are concrete animal oils, differing in their fusibility. Insoluble, in water—they are slightly acted on, when cold, by alcohol. Hot alcohol dissolves them, and deposites, on cooling, one portion, which is less fusible, but retains another. The first, or least fusible, compound, is called Stearin—the other, Elain. According to Chevreul, the first produces Margaric—the last, Oleic, acid—during the process of saponification.

tated in flocks, which, after a time, are changed into brilliant plates. This precipitate, is to be washed, until the washings do not become turbid by nitrate of silver. Gently dried, it becomes a yellowish-white lamellated powder, and does not redden litmus.

Uric Acid, dissolves in nitric acid, and yields, by evaporation, a residuum of a fine red tint. This property, assists in detecting it.

OF PYRO-URIC ACID.

When the uric acid is distilled, per se, another acid is generated, called by the name above mentioned. It rises, in the form of a yellow sublimate, in union with ammonia. This sublimate, being dissolved in water, and acetate of lead added to the solution, a white precipitate ensues, which, after due ablution, is decomposed by sulphuretted hydrogen gas—and, by solution, and evaporation, affords crystals of the Acid, in the form of white needles.

OF PURPURIC ACID.

From a solution of uric acid, in nitric acid, on the addition of ammonia, dark red crystals are separated, which are to be dissolved in a solution of potass, and subjected to heat, until the redness disappears. The solution, being then decomposed by diluted sulphuric acid, Purpuric Acid is precipitated, in a fine yellowish, or cream-coloured powder, without taste or smell—and which, when seen by a magnifier, exhibits a pearly lustre. Though it does not redden litmus, it is capable of saturating alkalies; and, when in aqueous solution with them, produces a beautiful deep carmine, or rose-red colour.

OF ROSACIC ACID.

The lateritious sediment, obtained from the urine of diseased persons, contains, according to the best authority, an acid,

OF CHOLESTERIC ACID.

There is, in the biliary calculi of men, a peculiar fat matter, which M. Chevreul calls Cholesterine. This, when treated with nitric acid, produces a peculiar acid, called Cholesteric Acid.

OF MARGARIC AND OLEIC ACIDS.

These acids, are said to be produced, during the process of saponification—also to be found in the fat of dead bodies.

OF PRUSSIC, OR, HYDROCYANIC ACID.

When potash is ignited, in contact with animal matter, cyanogen is formed, by the union of carbon and nitrogen. The new compound, enters into combination with the potassium, (of the potash) with which, it constitutes a cyanide, or cyanuret. The cyanide, thus created, being dissolved, and sulphate of iron added, a complicated reaction ensues. The cyanogen, gives up the potassium to the oxygen of the water and sulphuric acid—while the hydrogen of the water, and the oxide of iron, form with it a prussiate, or hydrocyanate, of iron. At the same time, a cyanide of iron is produced, and unites with the prussiate of iron—making, what has been called, a ferro-cyanate, or ferro-prussiate.

Boiled with potash, the cyanide of iron, and hydrocyanic acid, unites with the alkali—forming a ferro-prussiate, or ferro-cyanate, of potash.

Boiled with red precipitate, or red oxide of mercury, Prussian blue cedes its cyanogen to the mercury—forming a cyanide, analogous to the chlorides of the same metal.

Cyanide of mercury, heated, yields cyanogen—a gas, composed of nitrogen and carbon. Distilled with muriatic acid, it combines with the hydrogen of this acid, and forms Prussic, or Hydrocyanic Acid, which passes over, while the chlorine forms a chloride with the metal, and remains in the retort.

Milk is composed of cheesy and buttery matter, of sugar of milk, of different salts, especially phosphates, and a little acid. The cheesy and buttery matter, are only suspended in the Milk—whence its opacity; and, when evaporated, form a pellicle on its surface. By distillation, it yields water, slightly contaminated with milk. If heated daily, it does not spoil for a long time. It is extremely coagulable, by acids. Alcohol, in considerable quantity, coagulates Milk, by taking hold of the water; and the same result follows, from the admixture of other neutral substances attractive of water. Alkalies have the opposite effect, as they dissolve the cheese, which consists of fibrin and albumen.

Whey, as I have stated, contains sugar of Milk; and, besides this, some other animal matter, with phosphates and muriates.

The Milk of Women, contains less caseous matter, and more sugar, than Cows' Milk. It yields more cream, but not of a kind convertible into butter.

OF CHEESE.

OF CASEOUS OXIDE, AND CASEOUS ACID.

OF CHYLE, AND ITS INTERMEDIATE CHARACTER BETWEEN MILK AND BLOOD.

Chyle, is of a nature intermediate between that of milk and blood. Though susceptible, like the latter, of coagulation, the coagulum is more like cheese than fibrin.

Chyle contains albumen, a little fibrin, some saline matter, and a trace of oil and sugar.

OF THE MUCUS OF THE NOSE.

The Mucus of the Nose, besides water, which constitutes $\frac{93}{100}$ of it, consists of mucus proper, muriate of potash, muriate of soda, lactate of soda, albumen, and other animal matter.

OF TEARS.—OF THE AQUEOUS AND VITREOUS HUMOURS OF THE EYE.

Tears, are similar to the mucus of the nose, but more fluid.

The Aqueous, and Vitreous Humours, consist of water, albumen, and the usual neutral salts.

OF LYMPH.

Lymph, seems to consist, principally, of albumen, rendered soluble by an alkali. It contains some saline matter, especially muriate of soda.

OF SYNOVIA.

Synovia, contains about 80 parts water, 4½ parts albumen, and between 11 and 12 parts of fibrous matter—besides, some carbonate of soda, muriate of soda, and phosphate of lime.

OF URINE.

Urine is a very complicated fluid—being obviously secreted for the purpose of carrying off any excess of saline or other matter, received into, or formed in, the animal system.

Besides water, Urine contains acids, salts, alkalies, earths, gelatine, albumen, urea, sulphur.

The Acids, are the phosphoric, uric, fluoric, lactic, sulphuric, muriatic.

The Alkalies, are soda, potash, ammonia.

The Earths, are lime, magnesia, silica.

Of course, the Acids and Earths are, more or less, neutralized by each other—forming phosphates, urates, fluates, lactates, &c.

That there is an excess of acid in Urine, is evident, from its injuring colours. To the same excess of acid, is due the solution in it, of the otherwise insoluble earthy phosphates.

OF THE URINE OF HERBIVEROUS ANIMALS.

When phosphate of lime, predominates in a fragment of calculus, it first blackens, but soon after becomes perfectly white, and is very difficult of fusion before the blowpipe.—Calculi of this kind, are readily dissolved by dilute muriatic acid; and, when the acid is not in great excess, may be precipitated by oxalate of ammonia.

If a calculus, consisting principally of ammoniaco-magnesian phosphate, be subjected to a gentle heat, or moistened with caustic potash, an ammoniacal odour will be perceptible.

There is a species of calculus, which, when exposed to the blowpipe flame, bubbles up, and melts easily into globules, usually pearly, but sometimes transparent. This species, is called the Fusible Calculus. It is, principally, a mixture of phosphate of lime, and ammoniaco-magnesian phosphate. It is readily soluble in dilute muriatic acid—from which, the lime may be precipitated, by the addition of oxalic acid; and by adding ammonia, a precipitation ensues, of ammoniaco-magnesian phosphate.

The calculus, in which oxalate of lime predominates, is sometines called the Mulberry Calculus, from its resemblance to a mulberry. The heat of a spirit lamp, is generally adequate to destroy the acid, and to develop quick lime in this calculus, which may of course be detected by the alkaline tests.

Cystic oxide is recognized, *chemically*, by its great solubility in acids and alkalies.

OF BONES.

The Bones of Animals, consist of animal matter, indurated by phosphate of lime, with some carbonate of lime, still less phosphate of magnesia and fluate of lime, soda, and muriate of soda. The animal matter, is alleged to be gelatine, and albumen.

ELECTRICITY,

EXPERIMENTALLY ILLUSTRATED.

ORDER TO BE PURSUED, IN THE EXPERIMENTAL ILLUSTRATION OF ELECTRICITY.

Of the ordinary means of producing Electricity.—Communication of Electricity.—Different kinds of Electricity.—Means of accumulating Electricity.—Means of detecting Electricity.—Effects of Electricity.—Additional means of producing Electricity.—Theoretic explanation of Electrical Phenomena.—On the question, whether there be two Electric Fluids, or one only.—Means of Electrifying Patients; either with sparks, or by shocks.

OF THE MEANS OF PRODUCING ELECTRICITY.

It has been stated, in the preceding Lecture, that an attractive power is acquired, by resins, sulphur, glass, and a variety of other substances, when rubbed:—also, that bodies, susceptible of this species of excitement, are called Electrics—and the principle, on which it is supposed to be dependent, is called Electricity.

EXPERIMENTAL ILLUSTRATIONS.

Friction of amber, glass, resin, sulphur. Large glass tubes rubbed—also, cylinders of sulphur and of resin. Thin metallic leaves attracted, at a considerable distance, either by the glass, the sulphur, or the resin.

Electrical Machine exhibited, and explained.—Attraction of pith balls.

OF THE COMMUNICATION OF ELECTRICITY.

The electric virtue, cannot pass from one part of an electric which is excited, to another, without extraneous aid; nor can it pass off, from one electric, through any other.—Hence these substances are called non-conductors. Through metals, on the other hand, it escapes instantaneously. It passes with ease through a flaxen or hempen thread, but not through silk. Water, it pervades with great facility—or any thing which contains moisture.

Substances, which are thus capable of transmitting electricity, are called conductors—and are divided into perfect, and imperfect, conductors. The metals, are the only perfect conductors. All other conductors are imperfect; and, at the head of this class is charcoal, as being the best conductor of electricity, next to metals.

EXPERIMENTAL PROOFS, THAT ELECTRICITY DOES NOT PASS FROM ONE PART OF AN ELECTRIC TO ANOTHER, THROUGH, OR BY MEANS OF, THE ELECTRIC.

One part of a cylinder of sulphur, or of glass, being excited by friction, so as to attract light bodies—another part, not being rubbed, is not found to attract them.

Glass globe, or cylinder, on a pivot, being excited on one side by a wire (No. 1) proceeding from the Electrical Machine—the side, thus excited, is attracted by a wire (No. 2) on the other side, communicating with the floor, to which, as it approaches, it gives up its electricity. Meanwhile, other portions of the globe becoming excited by wire No. 1, are attracted by wire No. 2, and thus the globe revolves, in order to discharge its electricity.

A conducting mass, being placed on the pivots, in lieu of the electric, no revolution takes place. The

of woollen or silken strings, as in the case of those of flax or hemp. The glass rod, or the woollen or silken strings, being moistened, the electricity is carried off by them from the conductor; and moistening or drying the strings of hemp or flax, is found to heighten or lower their conducting power. The electricity escapes from the conductor, with ease, through a tube filled with water.

OF THE DIFFERENT KINDS OF ELECTRICITY.

It may be learned, from my brief account of the rise and progress of Electricity, (" History of Electricity," page 4) that the electrical excitement which may be produced in glass, by friction, differs from that which may be produced in resin, or sulphur: that light masses, as paper, or pith balls, separate from each other, when either excitement has been solely imparted to them—but if one body receives the resinous, the other the vitreous excitement, an attraction between them will ensue. Both excitements, in due proportion, neutralize each other. Also—whenever either excitement is produced, in one body, the other will arise in some other, if both bodies be supported on non-conductors, so as to prevent the escape of the electricity, as soon as generated. Hence if a person, standing on a glass stool, rub a tube of the same material, he will be found resinously electrified—while any body, to which the glass may be presented, will be vitreously electrified. A stick of resin, being substituted for the glass, and rubbed in like manner, and under the same circumstances, the same phenomena will appear, in a different order:—the person rubbing the resin, will be vitreously excited—while the excitement of the body, to which it is presented, will be resinous.

In like manner, when the cylinder of the Electrical Machine is put into motion, the insulated cushion which rubs it, acquires the resinous excitement—while the prime conductor

A glass vessel, filled with water to a due height, and moistened to the same height on the outside, may, as in the celebrated experiment of Cuneus, and Mushenbrœck, be charged and discharged, by the same means as the pane or phial coated with tin foil, though less advantageously.

Gold, silver, or copper leaf, metallic filings, or mercury, may be substituted for the coatings of a Leyden jar. When metallic filings are glued to the surfaces of a pane or jar, within the space usually allotted to the tin foil coatings, the discontinuity of the conducting surfaces, causes the passage of the electricity from one portion, to another, to become visible, and productive of a beautiful and interesting appearance.

EXPERIMENTAL ILLUSTRATIONS.

A glass pane, held by its insulating handle, is made to touch the knob of an excited conductor of the electrical machine, on one side----while another metallic knob, communicating with the other conductor of the machine, is made to touch the pane on the other side, in the part opposite to the first mentioned knob. By varying the situation of the knobs, the pane is charged, wherever its surfaces have been sufficiently in the vicinity of the knobs. While thus prepared, it is suspended by its handle, and one hand of the operator approximated to one side, while the other hand approximates the other. It can only be gradually discharged, as it was charged; the hands being made to assume, successively, the various positions relatively to the pane, previously occupied by the knobs. But, the pane being again charged by the knobs and coatings, duly applied; the surfaces are thoroughly and instantaneously discharged at once, by the contact of the hands, or other competent conductor. The coatings being applied to the pane, whilst charging, and then removed, the discharge can only be effected gradually.

Pane of glass charged by means of thin sheets of iron, in lieu of tin foil.

Charge and discharge of glass vessel, partially filled with water, and duly moistened on the outside:---- also of Leyden jar, coated externally with metallic filings:----also of a jar, coated internally with Dutch gold leaf.

Glass tumbler with moveable coatings, charged. The coatings being removed, and replaced, the tumbler is then discharged, as if the coatings had remained.

OF ELECTRICAL BATTERIES.

A series of coated jars, being placed side by side in a box, and all the inner coatings being made to communicate with each other, and with a ball of metal, by means of metallic rods—and all the outer coatings being made to communicate with eaah other, and with another metallic ball, by strips of tin foil; the jars, thus associated, are called an Electrical Battery.

Charging and discharging an electrical battery, however extensive, is just as simple, and is performed in precisely the same way, as in the case of a single jar. To charge a single jar, or a battery, the different coatings must be made to communicate, severally, with the different conductors of an electrical machine, either directly or indirectly, through the floor of the apartment, or other conducting medium.

To effect a discharge, either one or several conductors must be made to form a circuit from one coating to the other, either unbroken—or, if interrupted, the interval, or the sum of the intervals, must not exceed a certain distance, called the striking distance, and which varies with the extent and intensity of the electrical machine.

of jars which can be thus affected, is greater, or less, according to the intensity of the electricity evolved by the machine, and the aggregate thickness of glass interposed.

From a plate of mica, duly coated, and charged, a shock, far more severe, may be obtained, than from an equal extent of coated glass; because the glass is fractured, if as thin as the mica—and when thick enough to resist, the self-repellent power of the electric particles, which causes the jar to be charged, acts with less force, owing to the greater distance.

OF THE MEANS OF DETECTING ELECTRICITY.

It has been seen, during my experimental illustrations, that the property which light bodies have, of separating from, or approaching to, each other, when electrified, has been of use in showing the nature, and extent of electrical excitement.

A ball of pith, supported by a radius, which hangs on a pivot, so as to be capable of describing an arc of 90 degrees, over a corresponding curved scale—constitutes Henley's Quadrant Electrometer, employed in the experimental illustrations, page 11.

Bennet's Electrometer, has been already exhibited; in which, metallic leaves are suspended, within a glass cylinder, to a metallic cap—slips of tin foil are pasted on the glass, opposite, and parallel to, the gold leaves.

This last mentioned instrument, is sometimes, more properly, called an Electroscope—as it is better calculated to discover electricity, than to measure it.

The efficacy of the gold-leaf electroscope, is much increased by the addition of two vertical disks, one soldered to the cap, the other to the foot, by a hinge—so as that it may be placed parallel, and as near to the first mentioned disk as it can be, without touching. In this case, the capacity of the disk, attached to the cap, for electricity, is found to be increased, by *induction*—so that it will receive a surcharge. When the

EXPERIMENTAL ILLUSTRATIONS.

Effect of a point shown, in drawing a charge from a battery, or conductor:—proved, also, that its power is weakened, or destroyed, by being associated with an electric, or imperfect conductor.

ADDITIONAL MEANS OF PRODUCING ELECTRICITY.

OF THE ELECTROPHORUS.—OF ELECTRICITY, EVOLVED BY PRESSURE, BY CHEMICAL CHANGES, AND BY THE CONTACT OF HETEROGENEOUS METALS.

OF THE ELECTROPHORUS.

Let there be a cake of resin, the upper surface being as true a plane as can conveniently be made: also a metallic disk an inch or two less in diameter than the cake, with a glass handle cemented into a metallic socket, so that it may be held either by the socket, or the glass. Let the resin be rubbed with a dry cat's skin, then holding the plate by the socket, place it upon the resin—afterwards lift it by means of the glass handle, and bring the other hand near it. A spark will be received by the hand thus presented to the disk.—Replacing the disk on the resin, in the same way as at first, another spark may be had in like manner; and by a repetition of the process, sparks may be produced for a great length of time.

An electrophorus, being well excited in dry weather, will give sparks for many weeks, without being rubbed again.

RATIONALE.

The resin, being negatively excited by the friction—when the plate is laid down upon it, the electricity is less repelled on the side towards the negative surface, than externally, where there is no deficiency; it therefore flows into the plate, and charges it redundantly. When the plate is lifted, the proximity of the resin, which caused the redundancy, ceases, and of course the excess is given off, as soon as a conducting medium affords the opportunity.

A cake of resin, with a disk to create this species of excitement, is called an Electrophorus.

EXPERIMENTAL ILLUSTRATIONS.

Electrophorus exhibited, and explained. Method of exciting it, and obtaining sparks from it, shown.

OF ELECTRICITY EVOLVED BY PRESSURE.

There are many substances, wnich, if placed upon the disk of an electrometer, and pressed, will, on the cessation of the pressure, evolve enough electricity to be indicated by the gold leaf.

OF ELECTRICITY EVOLVED BY CHEMICAL CHANGES.

Among the sources of electricity, meteorological changes are by far the most prolific. When we compare thunder, with the noise of an electric discharge, whether from a conductor, or from a battery, we feel the comparative insignificance of electrical phenomena, artificially produced. Nor is the comparison more favourable, when a spark of a few inches in length, is contrasted with a forked flash of lightning, extending as many hundred feet.

But, whatever may be the disparity, between the phenomena of thunder and lightning, and those, of electrical discharges, produced by human ingenuity—I believe, no other difference is supposed to exist between them, by any electrician.

The assumption of the vaporous, or gaseous state, in many instances, appears to be satisfactorily accounted for, by supposing a union of ponderable matter, with caloric. Yet, the power of the electric spark, in effecting a union of the elements of water, of nitric acid, or ammonia; the explosive evolution of the oxygen, from oxygenated water, by the presence of oxide of silver; the inflammation of hydrogen, by platina sponge; prove, that there is much yet to be learned, respecting the association or reaction of imponderable agents, and of the part which they perform, in creating, or condensing aëriform matter.

It would seem, from the phenomena of thunder gusts, that the condensation of aqueous vapour, must cause the evolution of electricity, as well as of caloric. It is in this way only, that a destruction of the electrical equilibrium, can be imagined to arise, adequate to cause an emission of sparks from the clouds to the earth, so tremendous in effect.

Volta observed, that when coals are placed in a metallic recipient, on the cap of an electrometer, and sprinkled with water, the leaves are negatively electrified; while a metallic vessel, which condenses the vapour as it rises from the coals, becomes positively electrified.

Franklin, it is well known, drew electricity from the clouds, by means of a kite. Richman, of Petersburgh in Russia, lost his life, in operating with an apparatus, for the same purpose, which entered his apartment. Beccaria was not, by this, deterred from repeating the experiment, by means of a wire, of more than one hundred feet in length, at one time—and at another, by a rope, fifteen hundred feet in length, stretched over the river Po.

A wire, a mile long, insulated on poles one hundred feet high, is mentioned, by Singer, as having been erected by Crosse, an enterprising electrician. This wire communicated with an appropriate apparatus, in an apartment of the owner's house. The account of the phenomena which it produced, is very interesting. I give it in Mr. Singer's words :—

"The approach of a charged cloud produces sometimes positive and at others negative signs at first; but, whatever be the original character, the effect gradually increases to a certain extent, then decreases, and disappears, and is followed by the appearance of the opposite signs, which gradually extend beyond the former maximum, then decrease, terminate, and are again followed by the original electricity. These alternations are sometimes numerous, and are more or less rapid on different occasions; they usually increase in intensity at each repetition, and at last a full dense stream of sparks issues from the atmospherical conductor to the receiving ball, stopping at intervals, but returning with redoubled force. In this state a strong current of air proceeds from the wire and its connected apparatus; and none but a spectator can conceive the awful though sublime effect of such phenomena. At every flash of lightning an explosive stream, accompanied by a peculiar noise, passes between the balls of the apparatus, and enlightens most brilliantly every surrounding object, whilst these effects are heightened by the successive peals of thunder, and by the consciousness of so near an approach to its cause."

OF ELECTRICITY EVOLVED BY CONTACT OF HETEROGENEOUS METALS.

If a disk of copper, and a disk of zinc, be brought fully into contact with each other, face to face, from ten to twenty times—and after each contact, the copper disk be made to touch the cap of a condensing electrometer—it will be found, on separating the condensing disks of the electrometer, that the gold leaves will diverge.

tained by resin, is given out by glass. Hence, according to this theory, no less than Franklin's, the two electricities are always produced both by resin and glass; though the fluids retained in them respectively, being, in the first instance, separately recognized and associated with the substances in which they were observed, were named accordingly.

When a portion of a glass cylinder, or plate, is rubbed against a cushion, it gives off resinous, and receives vitreous, electricity. This surcharge of the vitreous fluid, is retained by the excited surface, until, in revolving, it comes opposite to the conductor. The increased capacity, created by the friction, ceasing, an equalization of the electricities, between it and the conductor, ensues; by which, the excitement is reduced, more or less, according to the extent of their respective surfaces. Returning to the cushion, the glass is re-excited, to the same degree, as it first; and, by a continuation of the process, gradually causes an exchange of vitreous for resinous electricity, between the conductors, until they are electrified, as oppositely, as the performance of the machine will permit.

Under these circumstances, if a conducting communication be made, between the oppositely excited bodies, the electricities rush together—neutrality ensues, and a total cessation of electrical phenomena.

The union of the two fluids, is supposed to be productive of the evolution of heat and light, which they absorb while separated.

In charging a Leyden jar, the two coatings become, for the time they are in communication with the conductors, respectively, a part of them. That which touches the resinous, or negative conductor, therefore, gives up its vitreous electricity, and receives resinous—while an opposite exchange, of resinous for vitreous, takes place in the other coating. When the charge is completed, the opposite electricities attract each other, through the glass, so as to keep each other on the surfaces which they respectively occupy; of course, a re-

intensity, into the air, in consequence of its carrying, along with it, the light encountered in its progress through ponderable matter. In like manner it may cause the extrication of caloric, by displacing it, when latent—or by adding temporarily to its repellent power, it may enable it to overcome attraction of cohesion;—in which case, a metal, no doubt, contains caloric enough to produce a violent, or even explosive, separation of the metallic particles.

ON THE QUESTION, WHETHER THERE BE TWO ELECTRIC FLUIDS, OR ONE ONLY.

This question has been discussed, in an essay which I published about eighteen months ago, in the Philadelphia Medical Journal, and which will be found in the Appendix to this Supplement.

I shall now confine myself, principally, to elucidating it by experiments.

EXPERIMENTS, TO ELUCIDATE THE QUESTION, WHETHER THERE BE TWO ELECTRIC FLUIDS, OR ONE.

Experiments with electrometers, in pleno, and in vacuo.

Electric spark, when emitted from a small knob from the positive conductor, compared with a spark obtained from the same, or a similar knob, attached to the negative conductor.

Positive and negative sparks, in vacuo, shown to be different—and that the difference is favourable to Franklin's hypothesis.

Exhibition and explanation of machine, with two glass cylinders, for demonstrating, that positive and negative electricity, are relative states of the same fluid.

Of three conductors, Nos. 1, 2, 3, it is shown, that No. 2 is vitreous, when tested by No. 1—but that, when tested by No. 2, it is resinous.

Sparks, passing between a neutral body and a conductor, positively or negatively excited, shown to differ only in length, from those which pass between oppositely excited conductors.

MEANS OF ELECTRIFYING PATIENTS, EITHER WITH SPARKS, OR BY SHOCKS.

A person, seated on an insulated chair, is made to communicate with one of the conductors; being thus negatively or positively electrified, sparks may be taken from any part of the body, by a metallic knob, or point. If the knob be too severe, the point may be used; and if this be too powerful, it may be covered by a wooden cone.

In order to subject a person to shocks, a coated jar is used, with two knobs—one connected with the inside coating, the other supported on an insulated wire, so that it may be made to approach, or recede from, the knob which communicates with the inner coating. To the outer coating, and the insulated knob, chains are attached, each terminating at one end in a knob of metal with an insulating handle. The handles are held by the operator, and the knobs applied to the patient, so as to leave between them, the part to be electrified. The coatings of the jar being severally connected with the different conductors, of an electrical machine, the charge increases in the jar, until it becomes strong enough to strike through the interval between the knobs connected with the inner coating, and that insulated in its vicinity. Of course, the height of the charge, depends upon the interval thus left—pursuant to the operator's discretion, or the feelings of the patient.

ON THE ORIGIN AND PROGRESS

OF

GALVANISM, OR VOLTAIC ELECTRICITY.

WITH Franklin's discoveries, the science of mechanical electricity had attained its meridian splendour. Subsequently, many years had elapsed, without any very important advance in that branch of knowledge. In the interim, the wonders of pneumatic chemistry, had occupied the most sagacious and ardent, among the cultivators of experimental science; and their brilliant discoveries had attained the zenith, when, fortuitously, the genius of investigation met with a new impulse.

It had been previously known, that when pieces of different kinds of metals, are placed above and below the tongue, their extremities projecting beyond it, and brought into contact, a pungent taste would be excited.

No further investigation took place, until Galvani, an Italian physiologist, engaged in the dissection of frogs, in order to explain the cause of convulsions which had been observed in those animals, when prepared for soup, and placed near an electrical machine. He ascertained, soon afterwards, that

cation of the electricity must cease, as soon as the accumulation at the poles becomes as great as it can be rendered, by the actual energy of the series. In this theory, the fluid is supposed to act, at first, as a non-conductor, in the next place, as a conductor—and no reason is given for the difference.

Moreover, Sir H. Davy, while he alleges, that the action of the fluid, in Galvanism, is upon atoms, instead of upon masses, agreeably to the wonted habitudes of the electric fluid—admits, that he can give no reason for this difference.

De Luc adopted Volta's view, of an electromotive power in the Voltaic series, independently of the chemical action of interposed agents; but, considered the oxidation of metals, as necessary to produce the shock, or chemical decomposition.—In support of his views, he constructed a very interesting apparatus, called the Electric Column; consisting of pieces of Dutch gold or silver paper, alternating with zinc. A series, thus formed, when extended to some thousands, gives sparks, and charges a Leyden jar—or produces vibrations in a pendulum interposed, by the opposite electrical attractions of its different poles.

It had been observed, that when Galvanic plates, of six or eight inches square, were employed, though not in a numerous series, the deflagration of metals might be produced, while the shock from them was hardly perceptible. Mr. Children, in consequence, made a series of twenty triads—two plates of copper enclosing one of zinc, and each sheet six feet by two feet eight. The effects of this combination, on metals, were prodigious. Five feet six inches of platina wire, of more than the tenth of an inch in diameter, were heated red hot. Other results, equally striking, were obtained.

About the same period, Sir H. Davy, by a more numerous, but smaller series, effected the decomposition of the alkalies and earths. When charcoal points, affixed to the poles of a series of two thousand pairs, constructed by him at the Royal Institution, were first brought nearly into contact, and then removed a few inches apart, an arch of igneous matter was

OF THE GALVANIC DEFLAGRATOR.

The motives, or views, which led to the construction of the Galvanic series, to which this name has been given—also the results which I obtained by it—are detailed, in a Memoir, and in a Letter to Professor Silliman, which will be found in the Appendix. I shall here confine myself, principally, to an explanation, and an experimental illustration, of its powers.

ILLUSTRATIONS.

Improved Galvanic Deflagrator of 300 pairs, exhibited, and explained. Deflagration, fusion, and volatilization of charcoal, anthracite, and plumbago, exhibited, agreeably to my observations, but more especially those of Professor Silliman:—Likewise of various metallic wires, of tin foil, tinsel, and mercury. Fusion and incorporation of iron and platina, under water. Hydrate of potash deflagrated upon charcoal, and upon a piece of silver coin.

Painful sensation experienced by the hands, when duly brought into the circuit.

effect, at the moment of immersion, is ten-fold greater, than afterwards, when the solution goes on with much greater rapidity.

I will here conclude my objections to the theories of others, and endeavour briefly to state my own views on the subject.

The power of Galvanic combination, to put into motion the imponderable, but material, causes of heat, light, and electricity, I conceive to be as occult, as the origin or nature of gravitation.

It seems to me, however, that, by Galvanic action—caloric, light, and electricity, are put into circulation, as collateral products; the proportion of the former, to the latter, being, (as already stated, page 41) as the extent of the metallic superficies subjected to the acid, to the number of pairs into which it may be divided;—that it is not improbable, that, by union with each other, these principles become more susceptible of transfer. Possibly, by such a union with each other, or with some unknown matter which regulates the Galvanic, and magnetic movements, they may escape our cognizance, while entering into, or passing out of, ponderable matter, in which chemical, or Galvanic changes, are taking place.

The effect of repose, upon Galvanic plates, in restoring their igniting powers, (whether connected or unconnected during the interval) argues in favour of a secret source, whence they renew their supply of igneous matter.

There are some other cases, in which the generation of caloric, and light, without some such occult causes, or properties, would be equally difficult to explain—especially, in that of the apparently unlimited extrication of heat by friction—the ignition of hydrogen by platina sponge—the explosion of oxygenated water with oxide of silver—the explosion of euchlorine, followed by expansion—the recomposition of water, by a spark from Voltaic wires, which, when immersed in it, cause its decomposition.

intermediate station, may be formed, from those of a ship, in sailing due east round the world; supposing her bow to answer to the north pole of the magnetic needle—her stern, to the south pole—and the axis of the globe, to the wire.—Supposing the poles of the earth to be reversed, in their astronomical relation, so that the north star should be over the part of the globe now called the south pole—the same changes would take place, in the various situations of the ship, relatively to an imaginary line through the earth's axis, as would be produced in those of the needle, relatively to the excited wire, should the direction of the Galvanic current through it, be reversed, so as to flow from north to south, instead of moving as before proposed.

By Mr. Ampere, a French philosopher of celebrity, it was ascertained, (not long after Oersted's discovery) that wires, completing the circuit of different Galvanic batteries, would attract and repel each other, but not in a mode analogous to electrical attractions—since it was between the terminations, similarly excited, that the attraction was observed, while the repulsion took place between terminations dissimilarly excited. Electrical indications are obtained, only, when the poles of the generating apparatus are unconnected; those afforded by the Galvanized wires, were the consequence of their connecting the poles of the Galvanic apparatus.

Not long after these observations, of Ampere, it was remarked, by Arago, Davy, and others, that the uniting wire was capable, like a magnet, of attracting iron filings—but incapable of attracting copper or brass filings, or sawdust.—Also, that a needle, placed transversely to the Galvanic wire, became permanently magnetic. This power, of imparting the magnetic property, was prodigiously increased, by forming the wire into spirals.

The polarity, given to the needle, varied, accordingly as the spiral was wound to the right, or to the left—or, the spiral remaining the same, the polarity varied with the direction of the current.

pressure, as well as on heat. Its temperature would be much more uniform than at present—and all its variations would be gradual. An interchange of position would incessantly take place, between the colder air of the upper regions, and the warmer, and of course lighter, air, near the earth's surface, where there is the most copious evolution of solar heat. Currents would incessantly set from the poles to the equator below, and from the equator to the poles above. Such currents would constitute our only winds, unless where mountains might produce some deviations. Violent gales, squalls, or tornadoes, would never ensue. Gentler movements would anticipate them. But the actual character of the air, with respect to elasticity, is the opposite of that which we have supposed. It is perfectly elastic. Its density is dependent on pressure, as well as on heat; and it does not follow, that air which may be heated, in consequence of its proximity to the earth, will give place to colder air from above. The pressure of the atmosphere varying with the elevation, one stratum of air may be as much rarer by the diminution of pressure, consequent to its altitude, as denser by the cold, consequent to its remoteness from the earth—and another may be as much denser by the increased pressure arising from its proximity to the earth, as rarer, by being warmer. Hence when unequally heated, different strata of the atmosphere do not always disturb each other. Yet after a time, the rarefaction in the lower stratum, by greater heat, may so far exceed that in an upper stratum, attendant on an inferior degree of pressure, that this stratum may preponderate, and begin to descend. Whenever such a movement commences, it must proceed with increasing velocity; for the pressure on the upper stratum, and of course its density and weight, increases as it falls; while the density and weight of the lower stratum, must lessen as it rises. Hence the change is, at times, so much accelerated, as to assume the characteristics of a tornado, squall, or hurricane. In like manner may we suppose, the predominant gales of our climate to originate. Dr. Franklin, long ago, noticed, that north-eastern gales are

standard of intensity, above and below which, all bodies electrically excited, are said to be minus, or plus.* It is perfectly consistent with this theory, that sparks should pass, as they are often seen to do, from conductors in either state—not only from one to the other, but to bodies nominally neutralized by their communication with the earth. As the difference between the electrical states of the oppositely electrified bodies, must be greater than between either of their states, and that of the great reservoir—the sparks between them will be longer, but, in all other characteristics, will be the same.—This practical result, is irreconcilable with the doctrine of two fluids—according to which, there can be no electricity in the earth, which is not in the state of a neutral compound, formed by these opposite electricities. For it would be an anomaly, to suppose, the reaction between a neutral compound, (a tertium quid) and either of its ingredients, to resemble, in intensity, and in its characteristic phenomena, the reaction which arises between the ingredients themselves.—As well might we expect aqueous vapour to explode with hydrogen or oxygen gas, as they do with each other.—Nothing can be more at war with the doctrine of definite proportions, of multiple volumes, and every analogy established by the chemistry of ponderable matter, than that two substances should combine, in every possible proportion, and with precisely the same phenomena; that they should be capable of neutralizing each other, and yet eagerly act as if never neutralized.

An argument in favour of the existence of two fluids, has been founded on the appearance of two burs, when a card is

* In some discussions which took place some years ago, between Mr. Donovan and Mr. De Luc, in Nicholson's Journal, it was erroneously charged against Franklin's doctrine, that he supposed that there was an absolute state of neutrality. The doctrine of one universal fluid, is, to me, obviously irreconcilable with that idea, otherwise than as above explained.—The quantity of electricity in the globe, is as unalterable in any sensible degree, as the quantity of water in the ocean; and it may therefore be assumed to be invariably the same.

DESCRIPTION

OF AN

ELECTRICAL PLATE MACHINE,

The Plate mounted horizontally, and so as to show both negative and positive Electricity.

Illustrated by Engravings.

The power of Electrical Plate Machines, has been generally admitted to be greater, than that of machines with cylinders. —The objection to the former has been, the difficulty of insulating the cushions, so as to display the negative electricity. —Excepting the Plate Machine contrived by Van Marum, I have read of none in which this difficulty has been surmounted. It is still insisted upon, by respectable electricians, as if it had not been sufficiently removed by his contrivance.

I presume, therefore, that a description of a Plate Machine, by which both electricities may be shown, and which, after two years' experience, I prefer on every account, may not be unacceptable to the public.*

My Plate (thirty-four inches in diameter) is supported upon an upright iron bar, about an inch in diameter, covered by a very stout glass cylinder, four inches and a half in diameter, and sixteen inches in height, open only at the base, through which the bar is introduced, so as to form its axis. The summit of the bar is furnished with a block of wood, turned to

* See plate I. fig. 3.

gold leaf will strike the ball, usually, if the one be not more than a twentieth of an inch, apart from the other.* Ten contacts of the same disks, of copper and zinc, will be found necessary to produce a sensible divergency in the leaves of the Condensing Electrometer. That the phenomenon arises from the dissimilarity of the metals, is easily shown, by repeating the experiment with a zinc disk, in lieu of a disk of copper. The separation of the homogeneous disks, will not be found to produce any contact, between the leaf and ball.

I believe no mode has been heretofore contrived, by which the electrical excitement, resulting from the contact of heterogeneous metals, may be detected by an Electroscope, without the aid of a condenser.

It is probable, that the sensibility of this instrument, is dependent on that property of electricity, which causes any surcharge of it, which may be created in a conducting surface, to seek an exit at the most projecting termination, or point, connected with the surface. This disposition is no doubt rendered greater, by the proximity of the ball, which increases the capacity of the gold leaf to receive the surcharge, in the same manner, as the uninsulated disk of a condenser, influences the electrical capacity of the insulated disk, in its neighbourhood.

It must not be expected, that the phenomenon above described, can be produced in weather unfavourable to electricity. Under favourable circumstances, I have produced it, by means of a smaller Electrometer, of which the disks are only two and a half inches in diameter.†

The construction, as respects the leaf, and the ball, regulated by the micrometer screw, remaining the same—the cap of a Condensing Electrometer, and its disks, may be substituted for the zinc disk.

* I have observed it to strike at nearly double this distance.

† I think I have seen an effect from a disk only an inch in diameter, or from a zinc disk, having a copper socket to its handle.

forty coils on one side, and a like number on the other.—This apparatus, when in operation, excited a sensation, scarcely tolerable, in the backs of the hands—and a most intense ignition took place, on bringing a metallic point, connected with one pole of the series, into contact with a piece of charcoal fastened to the other. A cylinder of platina, nearly a quarter of an inch in diameter, and tapering a little at the end, was fused, and burned, so as to sparkle and fall in drops. A ball of brass, of about half an inch diameter, was seen to burn on its surface with a green flame. Tin foil, or tinsel, rolled up into large coils of about three quarters of an inch thick, were rapidly destroyed, as was a wire of platina of No. 16. When platina wires in connexion with the poles, were brought into contact with sulphuric acid, there was an appearance of lively ignition.

Apprehending that the partition in the trough did not sufficiently insulate the poles from each other, as they were but a few inches apart, moisture or moistened wood intervening, I had two troughs made, each to hold forty pairs, and took care that there should be a dry space, about four inches broad, between them. They were first filled with pure river water, there being no saline nor acid matter to influence the plates, unless the very minute quantity which might have remained on them from former immersions. Yet the sensation produced by them, on the backs of my hands, was painful—and a lively scintillation took place, when the poles were approximated. Dutch gold leaf was not sensibly burned, though water was found decomposable by wires properly affixed.—No effect was produced on potash, the heat being inadequate to fuse it.

A mixture of nitre and sulphuric acid, being added to the water in the troughs, charcoal from the fire was afterwards vividly ignited—and when, attached to one pole, a steel wire was interposed between it and the other pole, the most vivid ignition which I ever saw, was induced. I should deem it imprudent to repeat the experiment without glasses, as my eyes, though unusually strong, were affected for forty-eight hours afterwards. If the intensity of the light did not produce an optical deception, by its distressing influence upon the organs of vision, the charcoal assumed a pasty consistence, as if in a state approaching to fusion. That charcoal should be thus softened, without being destroyed by the oxygen of the atmosphere, may be ascribed to the excessive rarefaction, or, as I suspect, to the protection afforded, by an atmosphere of volatilized carbon. This last mentioned impression arose from observing, that when the experiment was performed in vacuo, there was a lively scintillation, as if the carbon, in an aëriform state, acted as a supporter of combustion on the metal.

A wire of platina (No. 16) was fused into a globule on being connected with the positive pole, and brought into contact with a piece of pure hydrate of potash, situated on a silver tray in connexion with the other pole. The potash became red hot, and was deflagrated rapidly, with a flame having the rosy hue of potassuretted hydrogen.

A steel wire of about one-tenth of an inch in diameter, affixed to the negative pole, was passed up through the axis of an open necked inverted bell glass, filled with water. A platina wire, No. 16, attached to a positive pole, being passed down to the steel wire, both were fused together, and cooling, could not be separated by manual force. Immediately after this incorporation of their extremities, the platina wire became incandescent for a space of some inches above the surface of the water.

A piece of silvered paper about two inches square, was folded up, the metallic surface outward, and fastened into vices affixed to the poles. Into each vice a wire was screwed at the same time. The fluid generated by the apparatus, was not perceptibly conveyed by the silvered paper, as it did not prevent the wires severally attached to the poles, from decomposing water, or producing ignition by contact.

In my Memoir on my theory of Galvanism, I suggested, that the decomposition of water, which Wollaston effected

From the prodigious effect which moist air, or a moist surface, has, in paralyzing the most efficient electrical machines, I am led to suppose, that the conducting power of moisture, so situated, is greater than that of water under its surface. The power of this fluid, to conduct mechanical electricity, is unfairly contrasted with that of a metal, when the former is enclosed in a glass tube.

According to Singer, the electrical accumulation is as great when water is used, as when more powerful menstrua are employed; but the power of ignition is wanting, until these are resorted to. De Luc showed, by his ingenious dissections of the pile, that electricity might be produced *without*, or *with*, chemical power. The rationale of these differences, never has been given, unless by my theory, which supposes caloric to be present in the one case, but not in the other.—The electric column was the fruit of De Luc's sagacious inquiries, and afforded a beautiful and incontrovertible support to the objections which he made to the idea, that the Galvanic fluid is pure electricity, when extricated by the Voltaic pile in its usual form. It showed, that a pile, really producing pure electricity, is devoid of the chemical power of Galvanism.

We are informed by Sir H. Davy, that, when charcoal points in connexion with the poles of the magnificent apparatus, with which he operated, were first brought nearly into contact, and then withdrawn four inches apart, there was a heated arch formed between them, in which such non-conducting substances as quartz, were fused. I believe it impossible to fuse electrics by mechanical electricity. If opposing its passage, they may be broken—and if conductors near them be ignited, they may be acted on by those ignited conductors, as if otherwise heated; but I will venture to predict, that the slightest glass fibre will not enter into fusion, by being placed in a current from the largest machine or electrical battery.

compared with the Cruickshank trough, (fig. 6) in igniting metals, or carbon, the fifty pairs (fig. 4) were found greatly superior. The shock from the Cruickshank trough was more severe. You must recollect, that in former experiments, I found that Galvanic plates, with their edges exposed as they are in the porcelain troughs, used by Sir H. Davy, were almost inefficient, when used without insulation, as are the pairs of the deflagrator. This demonstrates, that an unaccountable difference is producible, in Galvanic apparatus, by changes of form or position.

Being accustomed to associate the idea of the zinc pole, in a Voltaic series, with the end terminated by zinc, and the copper pole, with the end terminated by copper, I was surprised to find that, in decomposing water, the oxygen was attracted by the wire connected with the copper end of the deflagrator, while the hydrogen went to the wire connected with the zinc end. Subsequently, however, it occurred to me, that, in the deflagrator, the zinc pole is terminated by copper, the copper pole by zinc—and hence the apparent anomaly, that oxygen appears to be attracted by copper, and hydrogen to be attracted by zinc.

The projection from the carbon, exposed between the poles, takes place at the negative pole of the pile, and not at the positive pole, as you have alleged; and thus your observation, that the current of igneous matter, is from the copper to the zinc, may be reconciled with the Franklinian theory.

The observations, which are the subject of this communication, combined with those which you have made, of the incapacity of the deflagrator, and Voltaic series in the usual form, to act, when in combination with each other—must justify us, in considering the former, as a Galvanic instrument, having great and peculiar powers.

Since the above was written, I have tried my series of three hundred pairs. The projectile power, and the shock, were proportionally great, but the deflagrating power was not increased in proportion. The light was so intense, that, falling on some adjacent buildings, it had the appearance of sunshine.

"In the historical sketch* I have already given of the facts as they were discovered, I mentioned that M. Oersted first ascertained the mutual action of the wire and the magnetic needle. He showed that the apparatus had power over the needle only when the connexion was completed, consequently the electricity must be in progressive motion, or forming a current, as M. Ampere states, before it can become magnetic. M. Ampere, then, discovered the fact that two electrical currents (using the word in his own sense) were capable of acting on each other, and producing entirely new electrical phenomena. This discovery was noticed in the former part of this letter,† and it was mentioned that when the currents were in the same direction, they attracted each other; when in different directions, they repelled each other. These attractions and repulsions differ entirely from those exhibited by electricity in a state of tension, as may be seen by referring back to the account given of them. M. Ampere nevertheless considers them as belonging to the electricity, but only when it moves in currents. They are, he thinks, dependent on certain properties which these currents possess, and are not produced by the action of any magnetic or other fluid which the electricity has set at liberty. Electricity, when accumulated, has the power of causing certain attractions and repulsions which are called electrical; when in motion it has the power of causing certain other attractions and repulsions; namely, those in question.

"Having then ascertained these new properties of electric currents, M. Ampere, in the progress of his reasonings, reverted back to Oersted's experiment, and removing one of the currents, he substituted a magnet in its place. The results were the same as before; the attractions and repulsions were of the same kind, and took place in the same manner; so that the effects which were known to be electrical with the two wires, were produced, when in place of one of them a magnet was used: only, the distribution of the powers in the magnet seemed to differ from that in the wire or current; for that power which is exhibited by one side of the wire is concentrated in one end of the magnet, and that power exhibited by the other side of the wire in the other end.

"On taking away the remaining wire, and substituting a second magnet for it, the two acted in the usual manner; but the action was found to be analogous to that of two electrical currents. So that M. Ampere was forced by his experiments, and the view he had taken of them, to conclude, that all the attractions, whether excited by two wires, a wire and a magnet, or

* The necessity of referring to this historical sketch, is superseded by that, given in this Supplement, page 53.

† *Annals of Philosophy, vol. ii. p. 275, New Series.* See Lectures on Electro-magnetism, page 55, 2d paragraph.

CALORIMOTOR.

Plate XV

Fig. 1.

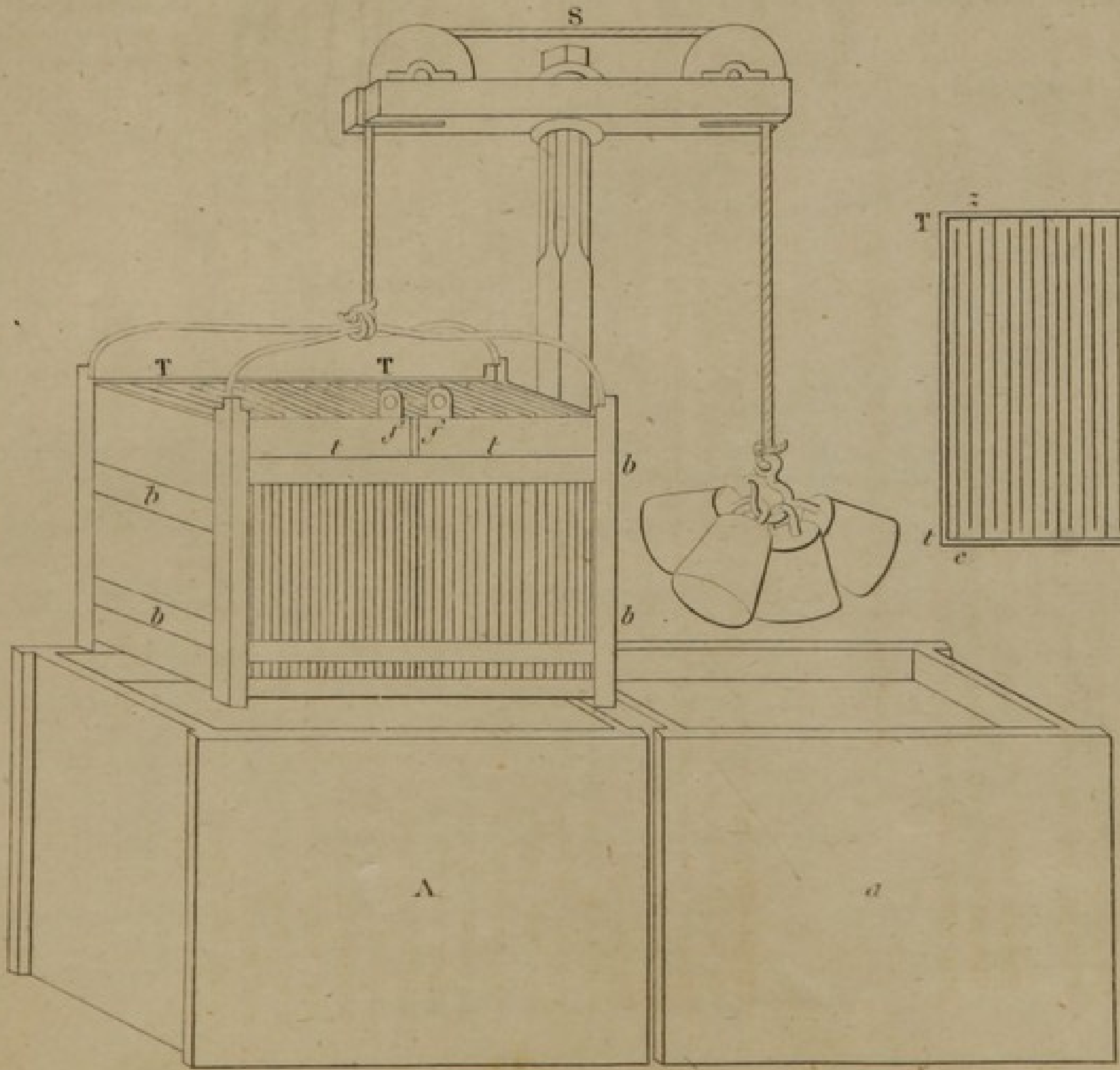


Fig. 2.

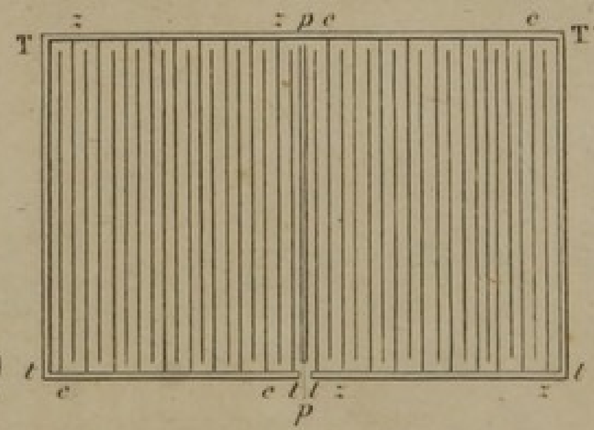


Fig. 3.

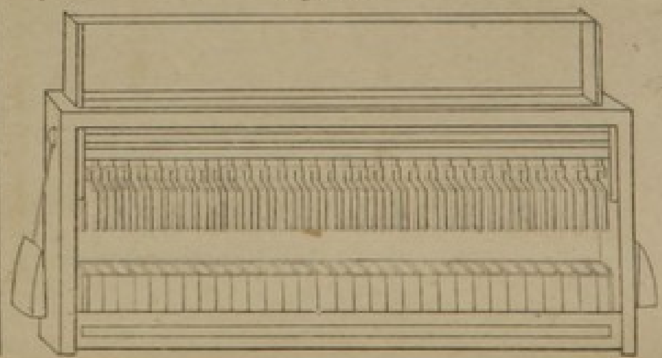
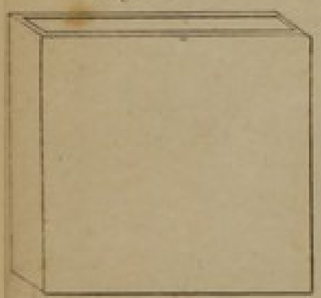


Fig. 4.



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